STIMULUS GENERALIZATION AND OPERANT DISCRIMINATION AS A FUNCTION OF LEVEL OF MOTIVATION

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A dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of
Philosophy in the Department of Psychology
in the Graduate School of Arts and
Sciences of Duke University

[illegible]

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A dissertation submitted in partial fulfillment of
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1961

Acknowledgments

I would like, at this point, to acknowledge the invaluable contributions of several individuals toward the completion of this dissertation and of the graduate training which it formally brings to a close.

To Dr. Norman Guttman, adviser and friend, I am especially indebted for his unfailing guidance and counsel throughout the course of the investigation and during the preparation of the manuscript. It was through his influence that I became interested in and aware of the intriguing problems in the subject area explored by this dissertation. This interest has been nurtured and reinforced by the friendship and encouragement of Drs. Harley M. Hanson and Werner K. Honig, for which I am most thankful.

I would also like, at this time, to acknowledge the influence of Dr. Gregory A. Kimble, not so much with regard to the dissertation but rather on my attitudes toward research and toward psychology in general. Dr. Kimble's enthusiasm for research and for scholarship is so great that all who come in contact with it cannot fail to be significantly influenced thereby.

I would like to thank the United States Public Health Service for providing financial support during the course of this investigation. In the summer of 1957 while pilot work on this study was

being done, I was a research assistant to Dr. Norman Guttman on Grant #M 1002. From September, 1957 through September, 1958 I held a U.S.P.H.S. Pre-Doctoral Research Fellowship, again under Dr. Guttman's sponsorship.

Finally, I would like to indicate here my indebtedness to my wife, Doris Homa Thomas, for her aid in all stages of the dissertation, from the running of the <u>S</u>s through the preparation of the final draft. It is hardly necessary to say that without her patience and her encouragement, this dissertation never could have been written.

D.R.T.

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Chapter I

INTRODUCTION

The primary purpose of this experiment was to investigate the relationship between level of primary motivation (hunger) and two basic phenomena of behavior, stimulus generalization and discrimination learning. The difficulty of the discrimination was also systematically varied so that interaction effects involving problem difficulty might be observed and utilized in the analysis of the main behavioral processes under scrutiny.

An additional problem which was investigated was that of the effect of discrimination training on a subsequently obtained generalization gradient. Procedures were employed which made possible

a separation of the effects of the physical difference between stimuli to be discriminated and the amount of discrimination training administered, on properties of the post-discrimination generalization gradient.

A final problem with which we were concerned was that of the relationship between stimulus generalization and the ease of formation of a subsequently learned discrimination. A number of different measures of discrimination learning were used and different aspects of previously obtained generalization gradients were utilized in an attempt to predict them.

The character of the present study was essentially empirical, but the data will also be examined for their bearing upon a set of important basic issues in learning theory which extend beyond those functional relationships which determined the experimental design.

In this first chapter we shall treat separately the major theoretical and empirical considerations with regard to each of the four major problems under study. In the chapter which follows more specific aspects of experimental design will be discussed with particular emphasis on differences between the present study and past ones.

I. Motivation and Generalization.

A convenient starting place for a theoretical treatment of the problem of motivation and generalization is with the Hullian framework. According to Hull (1943) the strength of a learned response is determined by a multiplicative combination of its associational and motivational components. The Habit Strength of a generalized response varies inversely with the distance along the stimulus dimension (in J.N.D. units) that the test stimulus is displaced from the original one. If the drive level of S is increased, the Reaction Potential of all generalized responses is increased proportionately. The behavioral consequence of this change in $_SE_R$ depends on the response measure used. Where a linear relationship is assumed to exist between $_SE_R$ and the response measure (as in the case of latency, amplitude and resistance to extinction) a given change in $_SE_R$ produces a proportional change in the strength of the response. Thus an increase in drive increases the size of the generalization decrement and thereby increases the "steepness" of the gradient. With the measure of Response Probability, an ogival relationship to $_SE_R$ is assumed, thus the influence of a given change in $_SE_R$ may be more than or less than proportional to the amount of change, depending on the phase of the ogival function involved. The resulting generaliza-

tion gradient may be "flattened" or "steepened," depending on the initial level of $_{S}E_{R}$.

The measure of response rate is not included in Hull's system and therefore none of the Hullian predictions are directly applicable here. Skinner (1949) has expressed the view that response rate is closely related to probability. However, it is not our purpose to evaluate specific derivations from Hullian theory. Such derivations require the arbitrary specification of several unknown values (for example, of $_{S}E_{R}$) and the goodness of the fit with the empirical data may depend more on the theorist's choice of constants than on the predictive value of the theory. The Hullian position does suggest, however, that drive level is a variable which significantly affects stimulus generalization, whatever the response measure employed.

A very different theoretical interpretation of the role of drive in stimulus generalization comes from the statistical learning theory of Estes (1950). Estes argues that although Hull attributes both stimulating and energizing properties to drive, all quantitative derivations involving drive level make use of the energizing function alone. If drives are treated as strong stimuli which are as conditionable as externally caused stimuli, then this alone may account for results frequently cited as evidence

for the energizing function. In the area of stimulus generalization, for example, Ss trained under high drive would be expected to produce more generalization than low drive Ss because stimuli associated with the drive state become conditioned to the responses. Such stimuli would be present even though the external stimulation was changed considerably, and thus drive stimuli would provide the basis for a good deal of generalization. The greater the level of motivation, the more intense the drive stimuli and the greater the weighting of these stimuli relative to external stimuli. Thus, the higher the drive, the "flatter" the generalization gradient.

A third view of the role of motivation in generalizaion is that of N. E. Miller. In Miller's theory of conflict behavior (1959) one of the postulates is: "The strength of tendencies to approach or avoid varies directly with the strength of the drive upon which they are based." Gradients of approach and avoidance are thought of by Miller as being typical of gradients of generalization. He assumes that an increase in drive increases the height of the entire gradient in an additive rather than a multiplicative manner. Miller feels that this assumption is necessary to account for the fact that if a rat is both shocked and fed at the end of a pathway, the distance that the rat will remain from

the goal varies with the intensity of the shock. Actually, such a result could occur even with a multiplicative effect of drive, if one wishes to invoke the mechanism of the reaction threshold, as does Hull. However, Miller believes that the evidence from studies such as Brown's (1942) lead to the acceptance of the additive alternative.

It may be seen that theorists fail to agree not only on the mechanism responsible for the effect of drive on generalization, but also on the nature of the predicted relationship itself. The empirical evidence in this area of study reflects the theoretical inconsistencies. Studies of the influence of drive on stimulus generalization have been performed varying the hunger drive Brown (1942), Rosenbaum (1951), Newman (1955), Jenkins, Pascal and Walker (1958), the shock fear drive Murray and Miller (1952), Rosenbaum (1953), the sex drive Macerone and Walton (1938), Beach (1942) and the manifest anxiety drive Mednick (1957). All of these studies offer some evidence for increased generalization, i.e. raised and/or "flattened" gradients, with increases in drive. On the other hand, two recent studies using the Taylor Scale Buss (1955), Fager and Knopf (1958) found no drive effect at all. Thomas and King (1959), employing a parametric procedure with four different levels of food deprivation in pigeons found a

non-monotonic relationship with an intermediate drive level producing the "steepest" generalization gradients.

Although it is clear that drive level may influence the stimulus generalization gradient, the exact nature of this influence is not readily apparent. One variable that is of demonstrated significance is the range of drive levels sampled. Another important factor is the measure of response strength employed. Unfortunately, however, there is not complete agreement among studies using similar measures and sampling similar ranges of drive. It is likely that further research will reveal still other variables which interact with the drive-generalization relationship.

II. Motivation and Discrimination Learning.

The Hullian system provides a basis for predictions about the role of motivation in the formation of a discrimination. Typically, use is made of a simple learning situation in which there are two known response tendencies, one of which is clearly dominant at the beginning of the experiment. The probability of a correct response depends, among other things, on the degree to which its $_SE_R$ value exceeds that of the incorrect response. The difference between the $_SE_R$ values of the correct and the incorrect response

varies directly with the level of drive. Thus, if the correct habit is dominant at the start of the experiment, increased drive will be facilitating; if not, increased drive will be inhibiting.

The literature contains a sufficient number of relevant studies to make an evaluation of the theory possible. A rather large number of studies have been reported in which differences in drive level had no demonstrable influence on selective learning, Meyer (1951), Myers (1952), Teel (1952), Champion (1954), Carlton (1955), and Miles (1959). On the other hand a facilitating effect of drive has been reported by Powloski (1953), Hamord (1954), Eisman (1956), and Eisman, Asimov and Maltzman (1956). Finally, a number of studies have been reported in which an intermediate level of drive has proved optimal for discrimination learning, Yerkes and Dodson (1908), Dodson (1917), Birch (1945).

Again, no explanation has been offered for the many discrepancies in the literature. Many different species have been employed and many different experimental procedures have been used to test them. The range of drive levels sampled and the different response measures used no doubt also contribute to the inconsistency of findings. It would seem desirable to study the problem of the effect of drive level on ease of discrimination learning in a situation in which the behavior of S and the nature of the stimuli

were both under the strictest possible control. This was one purpose of the present experiment.

III. Discrimination Training and the Stimulus Generalization Gradient.

At the very core of Spence's theory of discrimination learning in animals is the assumption that discrimination training produces some very definite changes in the resulting gradient of stimulus generalization. Spence (1936, 1937) assumes that reinforcement of a response simultaneously increases the strength of a class of responses (defined by the stimulus generalization gradient). On the other hand extinction of a response due to non-reinforcement results in a gradient of extinction or "inhibition". If both of these processes have taken place, either simultaneously or successively, and if the positive and negative stimuli are on a continuum, then the resulting tendency to respond to any stimulus on that continuum will be a function of the algebraic summation of the gradient of excitation minus the gradient of inhibition. The result of this summation process is to yield a gradient, the peak of which is displaced from the value of the positive stimulus in the direction away from the negative stimulus. It is on the basis of this resulting gradient that Spence is able to derive the

prediction of transposition without implying an ability on the part of the subject to respond to relationships as such.

Hanson (1959) has reported an experiment in which predictions based on Spence's theory were put to the test. Pigeon Ss were trained to key-peck at one wave-length of light and not at another. Then a generalization gradient was obtained covering a wide range of stimulus values including the positive and negative stimuli. Three different sets of (S+, S-) pairs were used in different groups of Ss. The derivation from Spence's theory accurately predicted: (a) increased steepness of the gradient in the region of S-; (b) low response level at S-; (c) displacement of the mode of the post-discrimination gradient; (d) increasing displacement of the mode with decreasing (S+, S-) difference. However, two findings were contrary to predictions: (e) the post-discrimination gradients were all higher than the control gradient; and (f) the height of the post-discrimination gradients did not vary with (S+, S-) difference. These latter results are incompatible with the assumption that a subtractive mechanism underlies discrimination learning in the free-responding situation.

In evaluating Hanson's findings it is important to note that he was not testing Spence's theory of discrimination learning, but rather an extension of this theory to the operant free-responding

situation. The theory was proposed for a simple single choice situation and Hanson's findings in no way reflect on the adequacy of the theory in the situation for which it was intended.

Hanson's findings do raise several interesting questions. Although he showed that the amount of peak-shift after discrimination training varies inversely with the (S+, S-) difference, his experimental design did not make it possible to investigate the manner in which this change in the gradient takes place. We may ask "What is the course of change in the location of the gradient along the stimulus dimension?" "What variables affect this course?" Hanson's finding that both time to criterion and amount of peak-shift vary inversely with (S+, S-) difference suggests the possibility that amount of training is the mechanism through which (S+, S-) difference has its effect on the generalization gradient. If this is so, then the applicability of a Spence-type excitation-inhibition analysis to the operant successive-discrimination situation is still further questioned. In the present study, these and related questions suggested by the work of Hanson are considered.

IV. Stimulus Generalization and Subsequent Discrimination Learning.

On a number of occasions in the course of the introduction we

have used the terms "generalization" and "discrimination" under the assumption that their meaning was sufficiently clear for our purpose at the time. However, it might be wise to stop at this point and give more explicit definitions of these and related terms so as to avoid possible misunderstanding later on. By Stimulus Generalization we refer to the tendency of a response learned to a particular stimulus to be made in the presence of other stimuli. If the stimuli are ordered along some dimension, a function showing the strength of the response to the different stimuli is called a Generalization Gradient. The term "gradient" is appropriate in view of the fact that as stimuli are used which are progressively further removed from the original, the strength of the response progressively decreases. This decrease in the strength of the response when the stimulus is altered is called the "Generalization Decrement". Just as the value of the generalization gradient for a given stimulus may be considered as a measure of generalization, so the generalization decrement indicates the degree to which a particular stimulus is discriminated from the original. To be specific, by Discrimination we refer to the tendency of a response learned to a particular stimulus not to be made in the presence of other stimuli. Just as generalization may be thought of as an innate property of learned behavior,

so discrimination may be similarly classified. By definition, generalization and discrimination are opposite and complementary processes; S generalizes to the degree that it does not discriminate and vice versa.

A common assumption seems to be that discrimination is more basic, and that generalization represents a failure of discrimination due to the limited sensory or perceptual capacity of the S. This capacity of the S determines stimulus Discriminability which is usually operationally defined in terms of the size of the difference threshold (J.N.D.). Studies which have concentrated on determining the nature of the relationship between discriminability and generalization have produced equivocal results. Whereas Kalish (1959) has presented evidence with human Ss which favors the assumption of an inverse relationship between generalization and discriminability, Guttman and Kalish (1956), working with pigeon Ss, were unable to find any support for this assumption.

In the present case we are interested in a different, though related problem, "What is the relationship between stimulus generalization and the ease of formation of a discrimination?" By Discrimination Learning or formation of a discrimination we refer to the establishment and/or increase in the tendency of S to respond differentially in the presence of different stimuli. In

the present case negative stimuli were selected which were sufficiently different from the C.S. to evoke a lower rate of response (generalization decrement), thus the effect of discrimination training was to increase a discrimination which already existed.

If discrimination learning involved no more than the extinction of a response to a generalized stimulus concurrent with the maintenance of the response to the original stimulus, then it might be predicted that the greater the generalized response strength to the negative stimulus, the longer will the mastery of the discrimination require. However, such an analysis does not take into account the generalization of the effects of reinforcement from the positive stimulus to the negative, and the concurrent generalization of the effects of non-reinforcement from the negative stimulus to the positive. The process of discrimination learning may be far more complex than simple extinction.

Another basis for the prediction of ease of discrimination learning might be the "relative slope" of the generalization gradient, i.e. the size of the generalization decrement relative to the response strength to the C.S. Those Ss in a group which produce the largest generalization decrements may be assumed to have a greater tendency-to-discriminate than the others. It seems reasonable to assume that these Ss will be the first to increase

this decrement to the point where the arbitrary criterion of discrimination learning is met.

On the other hand there may be no direct or simple relationship between untrained discrimination (generalization decrement) and readiness to learn a new discrimination. The first is a perceptual process, the second is a question of behavioral modifiability. Possibly the stimulus generalization gradient and its associated decrement supplies us with a static measure of S's stimulus preferences at the time of testing and yet tells us nothing about a separate dynamic process, the alteration of these preferences through learning. The question is an empirical one, and an attempt has been made in the present study to find an answer to it.

Chapter II

A COMPARISON OF THE PRESENT DESIGN WITH THAT OF PAST STUDIES

At the beginning of the introductory chapter four different problems in the area of stimulus generalization and generalization were introduced. The remainder of that chapter was devoted to a general discussion of the theoretical and empirical background of each of these problems. In this chapter we will discuss the manner in which the present study attempted to treat these different problems and the ways in which this treatment differs from that of previous studies. In this discussion, specific procedural detail will be omitted if it is not essential to the argument, since such details will be found in the chapter on method which follows.

I. Motivation and Generalization.

In an earlier section reference was made to two rather similar experiments, one by Jenkins, Pascal and Walker (1958) and one by Thomas and King (1959). Both of these studies were concerned with operant generalization in pigeons as a function of various levels of the hunger drive. Jenkins et. al. showed that increased drive raises and "flattens" the gradient; Thomas and King reported a non-monotonic relationship between drive and generalization slope, with an intermediate level of drive resulting in the "steepest" gradients. In this aspect the two studies are not necessarily in disagreement, since the Jenkins et. al. experiment employed only two different drive levels. Perhaps if the range of values used was as wide as that employed by Thomas and King a similar non-monotonic function would have been revealed.

The two studies differed mainly in the interpretation of the effects of drive increase. Jenkins et. al. argued that increased drive increases response strength and this in turn accounts for the increased "flattness" of the gradient. On the other hand, Thomas and King presented evidence for changes in "slope" as a function of drive level, independent of response strength differences. A number of procedural differences may account for this discrepancy. The two studies used different training procedures,

different testing procedures, different stimulus dimensions, etc. A difference which may be of particular significance is that in the Jenkins et. al. experiment a chronic hunger state was used, i.e. Ss were maintained at weight for all of the training and testing procedures, while the Thomas and King procedure made use of acute hunger, i.e. the deprivation level was adjusted at the time of the generalization test.

In the present experiment we have attempted to replicate part of the Thomas and King study with the exception that a chronic rather than an acute state of hunger was used. Pigeon Ss were trained to respond to a monochromatic stimulus patch and later were tested in extinction for generalization to other wave-lengths. Three different levels of drive were used, corresponding to 60%, 70% and 80% of ad libitum weight. Pilot work had indicated that Ss chronically maintained at 90% of ad lib. weight were not sufficiently motivated for proper training.

II. Motivation and Discrimination Learning.

In view of the evidence (Yerkes and Dodson (1908), Birch (1945) that the optimal level of motivation for the learning of a discrimination may vary with the difficulty of the problem, it would appear necessary in any study of drive and discrimination learning

to include a number of different discrimination problems representing a wide range of difficulty. For this purpose we selected three different problems: (a) 550Mμ, positive (+), 590Mμ, negative (-), (b) 550Mμ, +, 570Mμ, -, (c) 550Mμ, +, 558Mμ, -. Responding to positive stimuli was reinforced according to a variable interval (VI) schedule; responding to negative stimuli was never reinforced. Research by Hanson (1959) has indicated with similar stimulus values that time to learn the discrimination is an inverse function of (S+, S-) difference.

In order to examine possible interaction effects of drive level and problem difficulty it is essential to employ a number of levels of each variable. In the present study three different deprivation weights were used, 60%, 70% and 80% of ad lib. weight. The resulting factorial design makes it possible to analyze the effect of (S+, S-) difference, the effect of drive level, and the effect of the interaction of the two. As a dependent variable, the time to achieve the criterion of discrimination learning may be used. It is also possible to employ a variety of different discrimination learning measures, e.g. number of responses in training to S-, per cent of total responses to S-, etc.

III. Discrimination Training and the Stimulus Generalization Gradient.

Hanson (1959) has shown that the effect of discrimination training is to "steepen" the post-discrimination generalization gradient and to shift the peak of responding from the S+ value to a new stimulus in the direction opposite from the S-. The amount of this peak-shift varies inversely with the (S+, S-) difference. It was also demonstrated that the time required for mastery of the discrimination varied in a similar manner with (S+, S-) difference. The hypothesis may be entertained that the amount of discrimination training is the vehicle through which the (S+, S-) difference has its effect on the post-discrimination generalization gradient.

There are two different procedures which might be used to distinguish between the roles of amount of training and (S+, S-) difference. One would be to administer a fixed amount of discrimination training to two different groups of Ss, each with a different (S+, S-) difference. If the resulting post-discrimination gradients were similar, then the significance of amount of training independent of (S+, S-) difference would be established. On the other hand if the two gradients differed, the effect of (S+, S-) difference independent of amount of training would be shown. Another procedure would be to test Ss for generalization

following different amounts of training on the same problem, i.e. the same (S+, S-) difference. The greater the amount of training, the greater the amount of peak-shift should be.

The present experiment employed a design which incorporates both of the aforementioned procedures. Three groups of Ss, each assigned to a different discrimination problem, were subjected to tests of generalization after two sessions of discrimination training, four sessions, six sessions, etc., until the criterion of discrimination learning was reached. A comparison of the first generalization gradient obtained from each of the three problem groups reveals the influence of (S+, S-) difference with amount of training held constant. A comparison of the first generalization gradient with the second gradient, the third gradient, the fourth gradient, etc. for each individual S reveals the role of discrimination training with (S+, S-) effects held constant.

IV. Stimulus Generalization and Subsequent Discrimination Learning.

In the present study stimulus generalization gradients were obtained from the Ss before the start of discrimination training. This preliminary (pre-discrimination) generalization gradient provides the data from which a prediction of the ease of discrimination

learning may be made. More than one aspect of the generalization gradient might be employed for the prediction of subsequent discrimination learning. The ease of formation of a discrimination may be a function of the absolute strength of the generalized response to the negative stimulus, or it might be a function of the relative response strengths to the positive and negative stimuli. The number of responses to the negative stimulus and the ratio-responses to S- divided by responses to the CS were both used in an attempt to predict ease of discrimination learning.

Typically, time or trials to achieve a learning criterion or number of errors made (responses to S-) are used to measure discrimination learning progress. Such measures are not always highly correlated with each other and a complete analysis requires the inclusion of both kinds of scores. Such was the plan of the present experiment.

Chapter III

METHOD

Subjects.—The Ss were 54 experimentally naive white carneau pigeons obtained from the Palmetto Pigeon Plant in Sumpter, S.C. This number remained from an original group of 66 animals. The others were discarded at various stages of the investigation due to illness or death, failure to be magazine trained, failure to learn the key-pecking response, apparatus failure, etc. All Ss weighed between 460 and 560 grams when on a free-feeding schedule.*

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* Two Ss in the 60% group and one S in the 70% group failed to be magazine trained within five days and were discarded. One S in the 80% group, two Ss in the 70% group and one S in the 60% group were discarded for failure to key-peck train within five days. Five Ss in the 60% group weakened and died during

Apparatus.—A bank of four identical Skinner type key-pecking apparatuses was used. Each box had the following internal dimensions: width, 15½ in., depth, 14½ in., height 14½ in. Walls and ceilings were painted flat black; floors were of unpainted masonite. The S's key of translucent plastic was exposed through a 7/8 in. circular aperture placed 6½ in. above the floor on one wall of the box. Directly below the key in the floor of each box was a 1-in. circular aperture through which Ss had access to the food magazine. The magazine, which was operated by a motor-driven cam, allowed Ss approximately 4 sec. of access to food during each cycle. Between cycles the food was lowered beyond S's reach. A plexiglass light fixture with a 15 watt bulb, placed directly above and in front of the floor opening illuminated the opening and the magazine for the duration of each cycle.**

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* the course of the experiment. Whenever an S failed to complete the entire experiment, the data for that S were discarded and another S was run in its place.

** The magazines described above were not those originally installed in the boxes, but were put in after the original model proved to be prone to failure. The change was made after the first squad of Ss, containing members of all experimental groups, had been run. There is thus no reason to believe that this apparatus change had any significant effect on the results.

Aside from the stimulus light and the magazine light during magazine cycles, the boxes were in darkness throughout the experiment. One box, number one, was set aside for generalization testing. The source of illumination for the key in this box was a Bausch and Lomb diffraction grating monochromator, Model 33-86-40, equipped with a 108 watt, 6v. A.C. ribbon filament tungsten lamp. The monochromator grating, 1200 grooves per mm. was blazed for maximum intensity in the visible spectrum. The exit and entrance slits of the monochromator were set at 5 mm. providing a band-width of 16.5 Mμ. The source was operated at the same level, 15 amps., throughout the entire experiment.

Boxes 2, 3, and 4 were used for training purposes only. The keys in these were illuminated by 100 watt, 120 v. A.C. projection lamps. Positive and negative stimuli were provided by Bausch and Lomb interference filters. Each box was equipped with a "positive filter", (transmission peak 550Mμ) and a "negative filter (590 Mμ for box 2, 570Mμ for box 3, and 558Mμ for box 4). The brightness of the filter colors was matched to the monochromator colors by the addition to the filters of an appropriate number of pieces of exposed film (Polaroid No. D 77843). The matching was accomplished with the aid of a photomultiplier tube and its associated amplifier.

The three training boxes were set up to change stimuli automatically according to a pre-arranged schedule punched on a tape run on a Gerbrands Programmer. Throughout the experiment, masking noise was supplied to all boxes by a Grason-Stadler Noise Generator, Model 901.

Procedure.--Upon arrival at the laboratory, all Ss were weighed, individually caged, and allowed free access to food and water. To facilitate handling, tail and wing feathers were clipped. Throughout the entire course of the experiment, free access to water was always available in the home cages. The weight of all Ss was measured on the day of arrival and each day thereafter. Food deprivation was not begun until a stable weight level was achieved by each S. This precaution was taken in order to permit adequate specification of the various body weight levels later to be used.

After four to ten days a stable weight level was achieved by all Ss and food deprivation was begun. Ss were randomly assigned to three body weight levels, 80% of ad lib. weight, 70% and 60%. At the same time Ss were assigned to three different discrimination problems, thus creating nine groups of Ss, one for each combination of weight level and discrimination problem. Deprivation ceased for each S when the appropriate weight was reached. At this point, training was begun, according to the following

schedule.*

Day 1: The Ss were allowed to eat from the open magazine for three min. Most Ss did so readily, none requiring more than 15 min.

Day 2: By successively reducing the period of access to the food magazine Ss were trained to eat during the four sec. magazine cycle. Then 50 reinforcement cycles were presented.

Day 3: Fifty more reinforcement cycles were presented.

Day 4: For the first time, the key was illuminated by a light of 550mμ. Key-pecking resulted in continuous reinforcement. If Ss did not respond spontaneously within 30 min., key-peck training via successive approximations was initiated. Each S was allowed to make 50 reinforced responses before the day's training session was terminated. Ss which failed to do so after approximately one hour were returned to their cages. Training was again attempted on the next day and on successive days if necessary. Ss which failed to learn the key-pecking response after five days of training were discarded.

Day 5: Ss were returned to the boxes for 50 more reinforced

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* This schedule presents the sequence of experimental treatments. Limitations of time, apparatus failure, apparatus availability, etc., were such that most Ss required a few more days to complete the schedule of treatments than the minimal time indicated.

responses.

Days 6-10: Variable interval (VI) reinforcement was given for thirty 60-sec. stimulus-on periods alternated with 10 sec. stimulus-off (blackout) periods. The mean interval between reinforcements was approximately 60 sec., not counting blackout periods. One of the five VI sessions for each S in all groups was administered in box 1, the test box, so as to accustom Ss to the test box and to the monochromator-produced stimulus.

Day 11: Preliminary Generalization Testing.--Each S was placed in the test box for a five min. warm-up period of VI and then a generalization test in extinction. Eleven different test stimuli were used (510Mμ, 520Mμ, 530Mμ, 540Mμ, 545Mμ, 550Mμ, 555Mμ, 560Mμ, 570Mμ, 580Mμ and 590Mμ). The eleven test stimuli were randomized within a series, and six different random series were presented to each S. This resulted in a schedule of 66 stimulus presentations. Each stimulus presentation was for 30 sec. and was followed by a 10-sec. blackout period, during which the number of key-pecks in the preceding period was recorded and the stimulus was changed.

Day 12: Discrimination Training.--Each S was placed in the box in which it had been trained. All three discrimination groups were trained with the same positive stimulus (S+) 550Mμ, and differed only with respect to the negative stimulus (S-). Each

discrimination group consisted of 18 Ss, six at each of three body weight levels. These groups may be designated by the negative stimulus used: 590Mμ (trained in box 2), 570Mμ (box 3) and 558Mμ (box 4). During discrimination training responding to the positive stimulus was reinforced according to the same VI schedule previously used. Responding to the negative stimulus was never reinforced. The positive and negative stimuli were presented successively in a prearranged random order. Fifteen 1-min. intervals of S+ and fifteen of S- were presented each day. All stimulus changes were made during the 10 sec. blackout periods. The 30 stimulus presentations comprised three blocks of ten, and within each block there were five positive and five negative stimuli. Two different random series were prepared and these were randomly alternated within and between Ss. Discrimination training was continued until a criterion of no responding in five successive periods of S- combined with continued responding to S+ was achieved.

Day 14: Interpolated Generalization Testing.—While each S was in progress of discrimination training, a 3-series generalization test of 33 stimulus presentations was administered at the completion of every even numbered daily session of discrimination training (Days 2, 4, 6, etc.). Before returning to the home cage, S was placed in the test box, allowed a 5 min. VI warm-up period, and then the test was administered. If the discrimination

criterion was met on a day on which an interpolated generalization test was scheduled, the test was omitted.

Final Generalization Test.--On the day after the criterion for discrimination was met, a final generalization test was administered to each S. The final test was carried out in the same manner as the preliminary and interpolated tests, with the exception that 12 test series (132 stimulus presentations) were used.

Chapter IV

RESULTS AND DISCUSSION

In this chapter we will treat each of the four major problems separately. The results relevant to each problem will be presented and an interpretation of the findings will follow.

I. Motivation and Generalization.

Before inquiring about the influence of drive level on generalization we must first ask the question "Did the difference in deprivation weight result in any difference in VI performance of the three groups even before the administration of the generalization test?" The results of past experiments (Ferster and Skinner

(1957)) led to the expectation that there would be a positive relationship between amount of weight loss and response rate under the VI schedule. The daily VI records for all Ss are reported in Tables XIII, XIV and XV in the appendix. The mean response rate on the fourth and fifth day of VI training was used as a measure of performance. These scores showed a great deal of variability, ranging from a mean of 526 Rs to 1760 Rs. The mean number of responses for the 60% group is 1007.2, for the 70% group 1056.3, and for the 80% group 1063.3. These differences are not significant ($F < 1$, 2/51 df) (Table I).

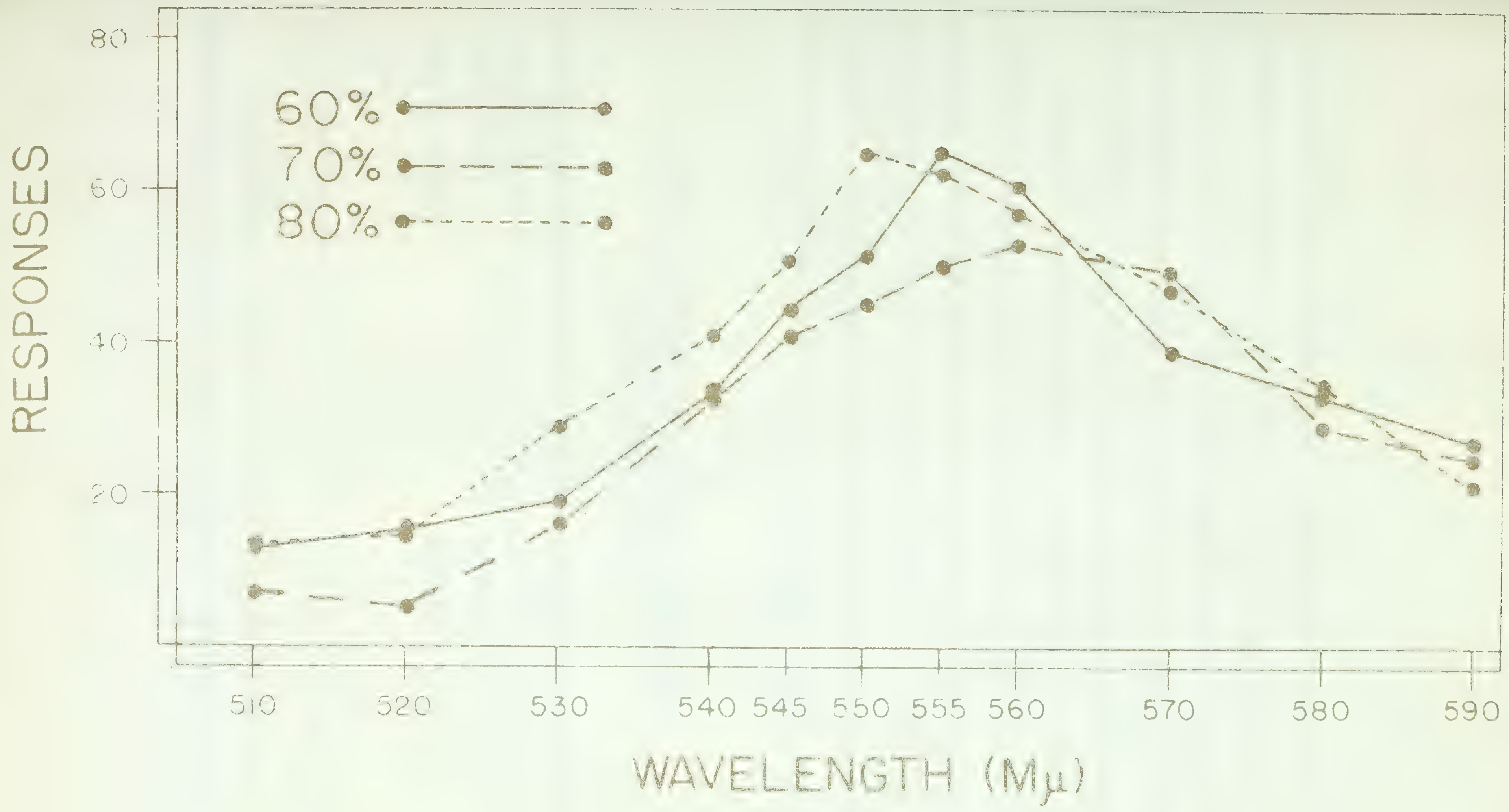
Table I

ANALYSIS OF VARIANCE OF VI RESPONSE RATE AS A FUNCTION OF DRIVE LEVEL

Source	df	MS	F
Drive level	2	16,863.2	0.13
Within groups	51	133,283.6	
Total	53		

Next we turn to the effect of drive level on the generalization gradient itself. The mean generalization gradients of the three drive groups are presented in Fig. 1. In Fig. 2 are presented the generalization gradients of the three drive groups,

Fig. 1. Stimulus Generalization Gradients at Three Drive Levels


60%
70%
80%
RESPONSES
80
60
40
20
510
520
530
540
545
550
555
560
570
580
590
WAVELENGTH (Mμ)

transformed in the following manner. For each S the gradient is plotted in terms of the per cent of the total response output given to the various stimuli. This transformation equates the area under all curves thus cancelling out differences due to response level, and thereby removing a major source of variability in the scores.

Inspection reveals that Fig. 1 and Fig. 2 do not differ greatly. The effect of the transformation of the individual gradients is not obvious because the total number of responses made in the test by the three groups did not differ ($F < 1$, 2/51 df) (Table II). The transformation does, however, reduce the variability of the scores which are used to compute the means in Fig. 2.

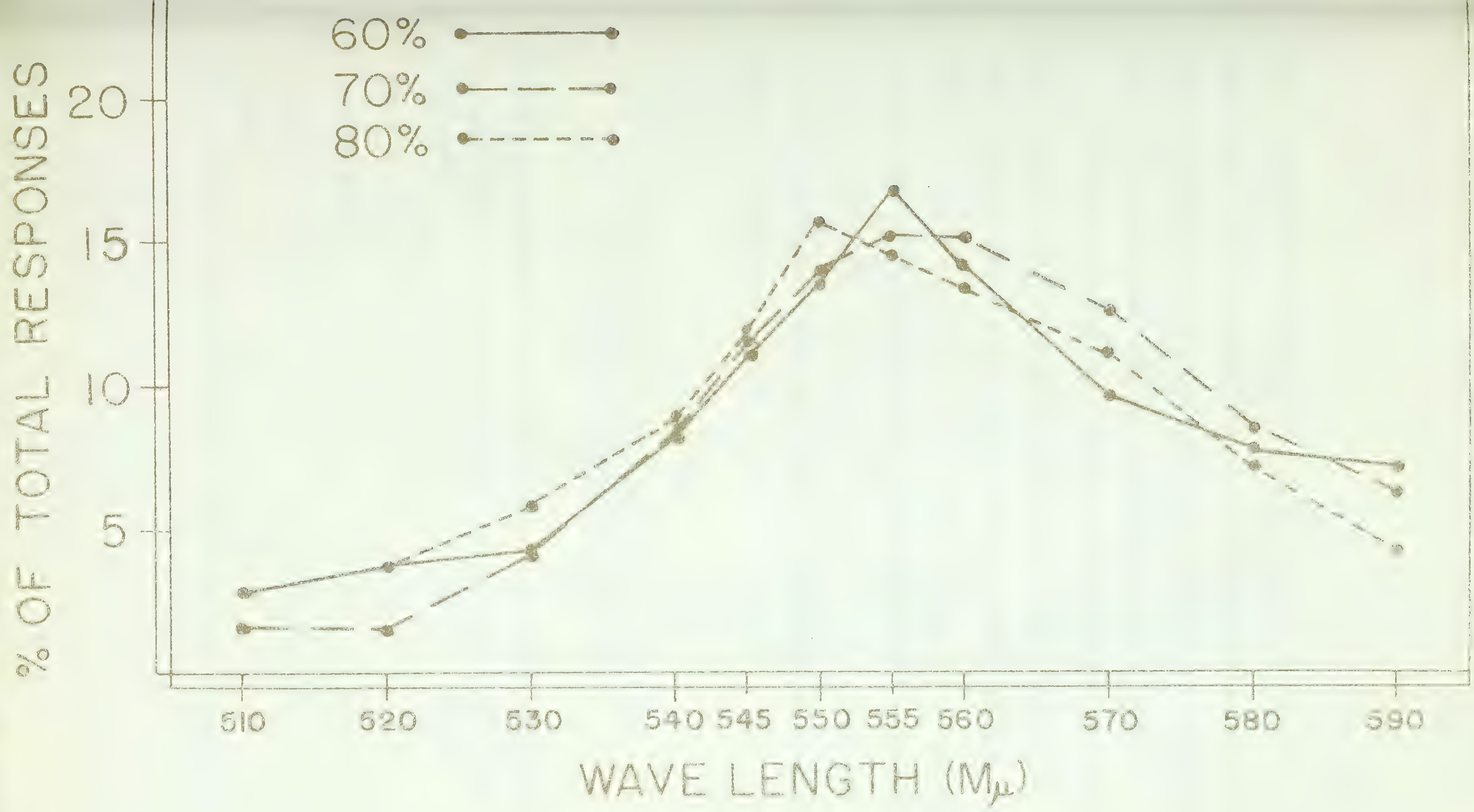
Table II

ANALYSIS OF VARIANCE OF NUMBER OF RESPONSES ON THE PRELIMINARY GENERALIZATION TEST AS A FUNCTION OF DRIVE LEVEL

Score	df	MS	F
Drive level	2	26,880.1	0.33
Within groups	51	80,533.1	
Total	53		

The gradients in Fig. 2 are unusual in a number of ways. They are "flatter" than those usually obtained. In addition they

Fig. 2. Stimulus Generalization Gradients in Terms of Per Cent of Total Responses at Three Drive Levels


60%
70%
80%
% OF TOTAL RESPONSES
20
15
10
5
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

show considerable tendency for the peak of responding to be displaced from the CS to a point toward the longer wave-lengths. In fact, the 60% and 70% gradients show more responding to 555Mμ than to 550Mμ (the CS) while the 80% group shows almost as much.

One way to analyze the location of the gradient is to treat it as a grouped frequency distribution and to compute the mean value. This yields a convenient measure of central tendency which does not require extrapolation from known values, (as in the case of the mode) and yet is sensitive to differences in the ends of the gradient (unlike the median). The analysis of the means of the three gradients shows no significant differences in location (F=2.00, 2/45 df)(Table III).

Table III

ANALYSIS OF VARIANCE OF MEANS OF THE PRELIMINARY GENERALIZATION GRADIENTS AS A FUNCTION OF DRIVE LEVEL AND PROBLEM

Source	df	MS	F
Problems	2	15.01	0.60
Drive level	2	50.28	2.00
Interaction	4	8.64	0.34
Within	45	25.09	
Total	53		

A simple measure which reflects the "slope" of the generalization gradient is the per cent of the total number of responses given to the CS value. The greater this per cent, the "steeper" the gradient. Although the 80% gradient is "steepest" and the 60% gradient "flattest" according to this measure the differences are not statistically significant. ($F = 1.74$, 2/51 df) (Table IV).

Table IV

ANALYSIS OF VARIANCE OF PER CENT RESPONSES TO CS ON THE PRELIMINARY GENERALIZATION TEST AS A FUNCTION OF LEVEL OF DRIVE

Source	df	MS	F
Drive level	2	24.89	1.74
Within groups	51	14.27	
Total	53		

In the present experiment the variable of deprivation weight level had no effect on either the level of responding to the CS during VI training or on the gradients of stimulus generalization obtained in extinction. Since both of these findings are contradictory to the results of past experiments, an explanation for these differences must be sought. The lack of a drive effect on VI rate might be explained by the fact that only five days of VI

training were given. If the influence of drive on VI rate is to raise the asymptote but not to effect the rate at which this asymptote is achieved, then perhaps more days of VI training would have been necessary to produce the expected drive effect. Another possibility to be considered is that 60% deprivation weight is so severe a condition that inanition substantially reduces the response strength of the Ss. The high mortality rate in the 60% group adds support to this hypothesis.

The lack of a drive effect on generalization is equally difficult to explain. In the present experiment there was no relationship between drive level and number of responses in the generalization test. There was also no reliable evidence that drive altered the slope of the gradient. It may be remembered that it is the position of Jenkins, Pascal and Walker (1958) that such influence as drive may have on the generalization gradient is mediated through changes in response strength. Such a view would lead to the prediction that since, in the present case, drive had no effect on response strength it would have no effect on generalization slope either. Our findings are thus consistent with their view although they certainly do not preclude another explanation. It may be that the unknown factors which prevented drive from influencing VI rate in the usual way also acted to prevent drive from influencing generalization slope. What such

factors might be it is not possible to infer from the data.

The present study indicates that much remains to be learned about the ways in which drive level affects behavior and the conditions under which such effects may or may not be observed. A number of problems are pinpointed on the basis of our failure to find a significant drive effect. One of these is the significance of the amount of training given the S prior to the generalization test. In the present study only five days of VI training were administered while all previous studies employed more extensive training. Another problem concerns the separation and spacing of generalization test stimuli. In the present experiment the stimuli were closely and unevenly spaced, being separated by 5Mμ units near the CS and 10Mμ units further away. What effect this variable may have remains to be demonstrated, but the results of the present study suggest the need for an exploration of this possibility.

II. Motivation and Discrimination Learning.

The discrimination learning waves of all Ss are presented in Table XXII in the appendix. In that table are recorded the cumulative response totals to both the positive and the negative stimuli. Since the procedure employed here required that Ss be

run to a criterion, different Ss received different amounts of training. Although it is possible to vincentize the curves and then analyze for difference directly, such a procedure assumes that the curves are of the same form, and in any case it also obscures much of the data. Instead we decided to employ measures of discrimination learning which can be calculated from the raw data themselves.

In the present study four different measures of discrimination learning were used. Two of these involved the passage of time; the number of minutes of training to criterion, and the number of minutes to one half the total response output to the negative stimulus. The first of these measures is straight-forward. It is the measure of discrimination learning used by Hanson (1959) and many other investigators. The second measure was introduced because it might be sensitive to differences overlooked by the first. For example, if, under one experimental condition, discrimination proceeds rapidly at first but then remains for a while on a plateau short of the criterion of learning, there might be no measurable difference between this condition and one which produced a more typical form of performance curve. On the other hand, the use of a criterion less rigorous might have shown a clear difference between the conditions. The use in this study of the second measure, the number of minutes to one half the total response output

to the negative stimulus, is thus a protection against possible error caused by the arbitrary selection of the learning criterion. The other two measures of discrimination learning are the number of responses given to S- in training and the per cent of the total number of responses in training which were made to S-. The analyses of discrimination learning in terms of the four different performance measures will be presented in the order outlined above.

Time to Criterion of Extinction.--Fig. 3 presents the data on time to criterion as a function of (S+, S-) difference with drive level as parameter. Analysis of variance indicates that minutes to criterion varies as a function of (S+, S-) difference ($F = 23.5$, 2/45 df, $p < .01$) (Table V). The effect of drive level approaches significance ($F = 2.96$, 2/45 df, $.05 < p < .10$) (Table V). The interaction between (S+, S-) difference and drive level is not significant ($F < 1$, 4/55 df) (Table V).

Time to One Half the Response Total to S-.--Fig. 4 presents the data on time to one half the total response output to S- as a function of (S+, S-) difference with drive level as parameter. Analysis of variance indicates that this measure varies as a function of (S+, S-) difference ($F = 18.68$, 2/45 df, $p < .01$) (Table VI). The effect of drive level approaches significance, ($F = 2.84$, 2/45 df, $.05 < p < .10$) (Table VI). The interaction between (S+, S-)

Fig. 3 Time to the Criterion of Learning as a function of (S+, S-) Difference at Three Drive Levels

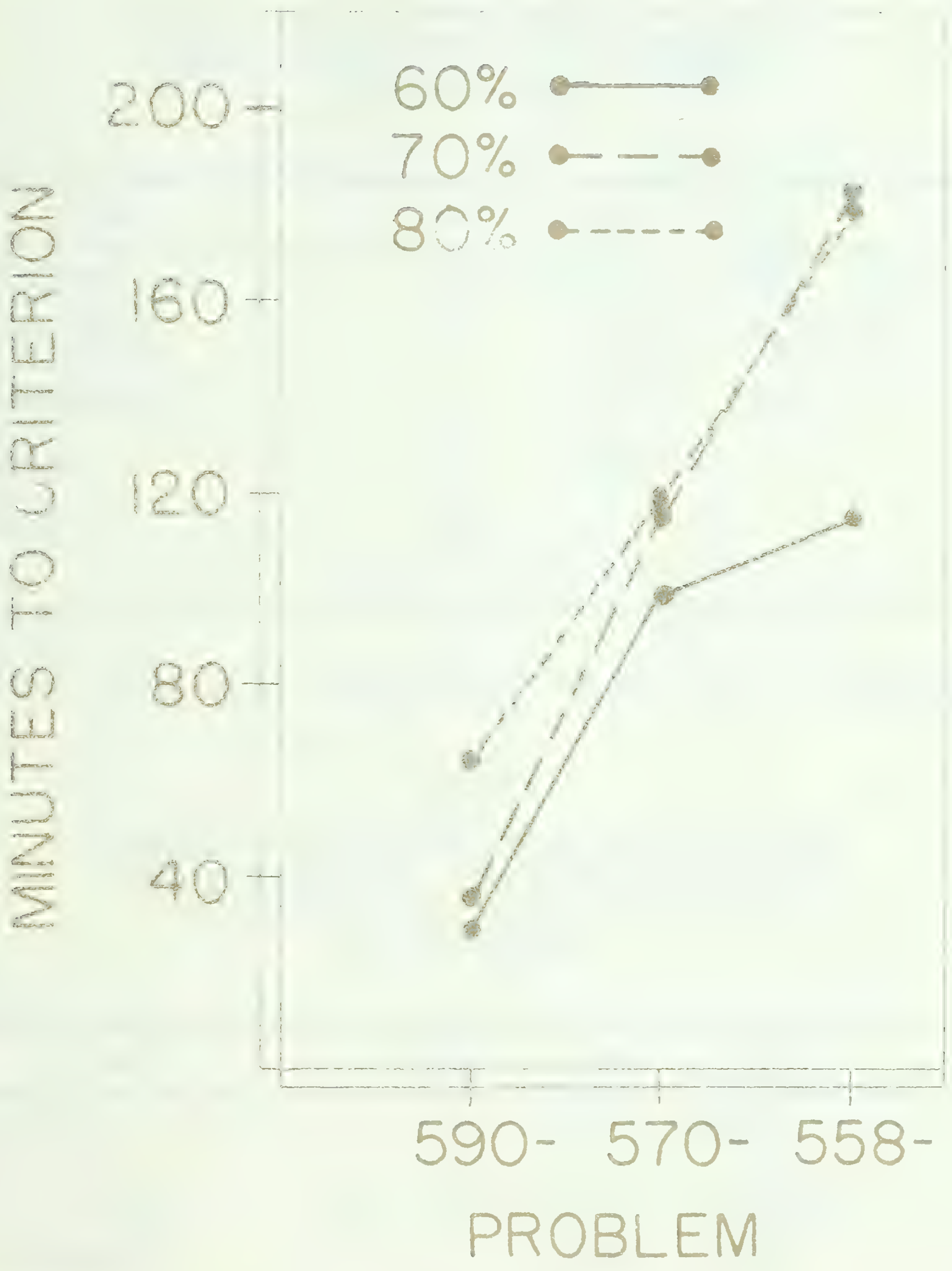
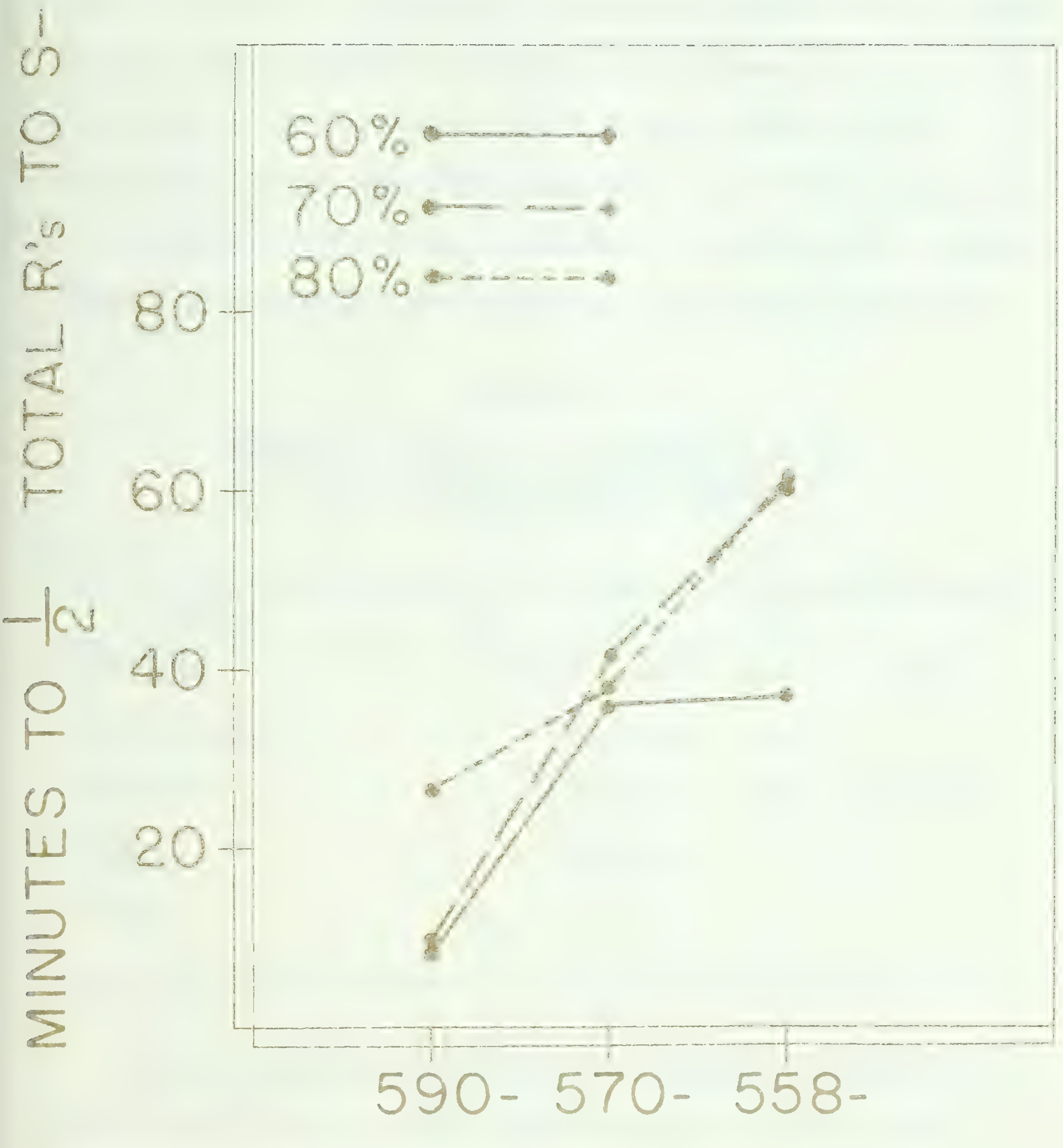

60%
70%
80%
200
160
120
80
40
MINUTES TO CRITERION
590-
570-
558-
PROBLEM

Fig. 4. Time to one half the Response Total to Ss as a function of (S+, S-) Difference at Three Drive Levels


60%
70%
80%
80
60
40
20
MINUTES TO ½ TOTAL R's TO S-
590-
570-
558-
PROBLEM

Number of Responses to S- during Training.—Fig. 5 presents the data on number of responses to S- during training as a function of (S+, S-) differences with drive level as parameter. Analysis of variance indicates that number of responses to S- varies as a function of (S+, S-) difference ($F = 15.06$, 2/45 df $p < .01$) (Table VII) but not with drive level ($F = 1.55$, 2/45 df) (Table VII) The interaction between (S+, S-) difference and drive level approaches significance ($F = 2.49$, 4/45 df, $.05 < p < .10$) (Table VII).

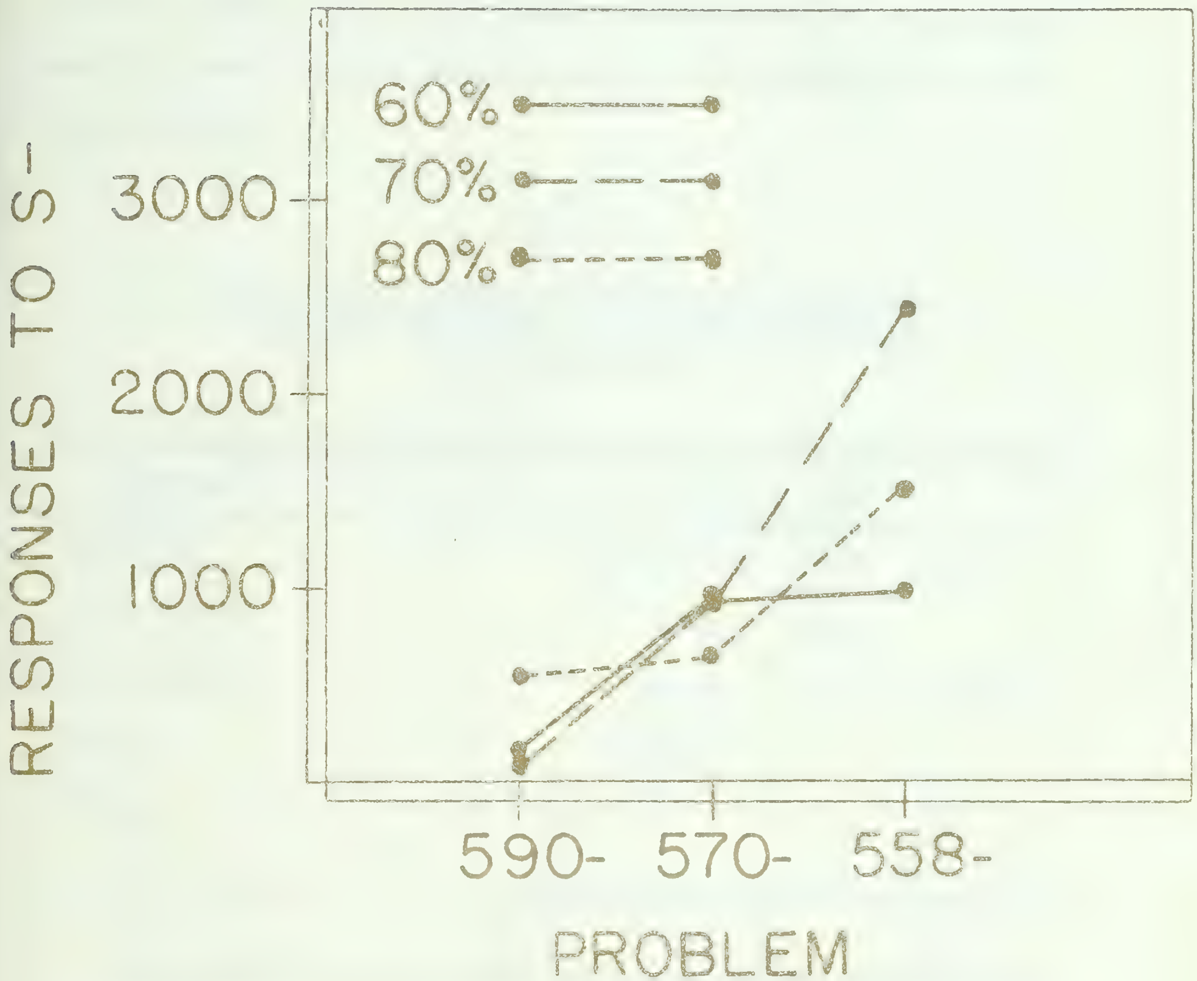
Table VII

ANALYSIS OF VARIANCE OF RESPONSES TO S- AS A FUNCTION OF (S+, S-) DIFFERENCE AND DRIVE LEVEL

Source	df	MS	F	
Problems	2	8,784,788.2	15.06	$p < .01$
Drive level	2	904,671.2	1.55	
Interaction	4	1,455,394.5	2.49	$.05 < p < .10$
Within	45	583,226.2		
Total	53			

Per cent of the total number of responses given to S-.—In Fig. 6 are presented the data for per cent of the total number of responses given to S- as a function of (S+, S-) difference with

Fig. 5. Number of Responses to S- during Discrimination Training as a function of (S+, S-) Difference at Three Drive Levels


60%
70%
80%
3000
2000
1000
RESPONSES TO S−
590-
570-
558-
PROBLEM

drive level as the parameter. Analysis of variance indicates that this measure varies with (S+, S-) difference ($F = 32.54$, 2/45 df, $p < .01$) (Table VIII) but not as a function of drive level ($F < 1$, 2/45 df) (Table VIII). The interaction between (S+, S-) difference and drive level is significant ($F = 4.38$, 4/45 df, $p < .01$) (Table VIII).

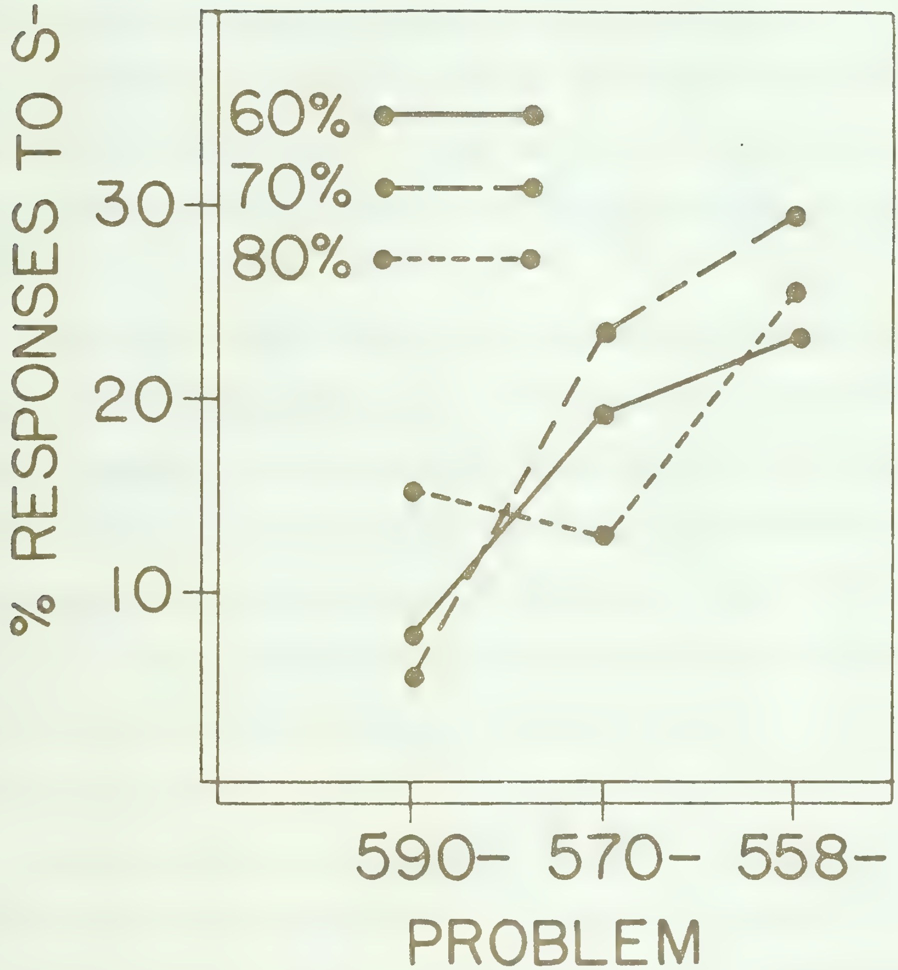
Table VIII

ANALYSIS OF VARIANCE OF PER CENT OF RESPONSES TO S- AS A FUNCTION OF (S+, S-) DIFFERENCE AND DRIVE LEVEL

Source	df	MS	F	
Problems	2	1,235.16	32.54	$p < .01$
Drive level	2	35.68	0.94	
Interaction	4	166.21	4.38	$p < .01$
Within	45	37.96		
Total	53			

The present study is fully in agreement with Frick (1948), Raben (1949) and Hanson (1959) in the finding that the ease of formation of a discrimination varies inversely with the (S+, S-) difference. This study expands upon Hanson's finding by using four different discrimination measures, each of which was found to

Fig. 6. Per cent of Total Responses to S- during Discrimination Training as a function of (S+, S-) Difference at Three Drive Levels


% RESPONSES TO S-
60%
70%
80%
30
20
10
590-
570-
558-
PROBLEM

be significantly related to the (S+, S-) difference. In two of the four discrimination learning measures, time to criterion and time to one half the total response output to the negative stimulus there was evidence to suggest that drive facilitates the learning of the discrimination. On the other hand the two other dependent variables, number of responses to S- and per cent of the total number of responses to S- during training showed no drive effect.

If the drive effect suggested by the two "time" measures is indeed reliable this would not be the first time that "time" and response strength or error measures failed to agree. For example, it was in Estes' (1944) classical experiments on punishment that it was shown that electric shock delivered to the rat during extinction of the bar pressing response may reduce the "reflex reserve" without altering the time required to achieve the criterion of extinction.

Although the present experiment cannot be said to demonstrate unequivocally that drive is a significant variable in determining the rate of the learning of an operant discrimination it suggests that this may be the case. It may be that the interpolation of two additional experimental treatments, the preliminary generalization test and the short generalization tests during the course of discrimination learning, increased the variability of

the learning scores so as to reduce the statistical level of confidence of the drive effect. The results are sufficiently promising to warrant a more direct attack of the problem of drive and operant discrimination learning. Whatever may be the theoretical significance of success or failure to find an effect of drive on discrimination learning. It is clear from the present study that the physical similarity or difference between the stimuli to be discriminated is of far greater practical importance than is the level of motivation of the S.

The finding of an interaction between drive level and (S+, S-) difference with the measures of responses to S- and per cent of responses to S- is difficult to interpret. The "Yerkes-Dodson Law" predicts an interaction between drive level and problem difficulty with the measure of rate of learning but no such interaction was found. Instead, there is an interaction between drive level and (S+, S-) difference with the measures of response strength to the negative stimulus. However, the nature of the interaction is different from that suggested by the results of Yerkes and Dodson (1908). The "Yerkes-Dodson Law" predicts that the highest drive level will be optimal with a simple problem, with lower levels of motivation being better for more difficult problems. The nature of the interaction obtained here, however, is as follows. With both the measures of responses to S- and per cent of total responses

to S-, with the most difficult problem, the highest level of drive is optimal, and with the problem of middle difficulty the lowest drive level is optimal, and with the easiest problem the middle level of drive is best. There is no explanation of this interaction which comes readily to mind.

III. Discrimination Training and Subsequent Generalization.

Compared to the preliminary generalization gradients, the post-discrimination gradients (PDGs) are more uniform and "steeper". Fig. 7 presents the gradients of the three different problem groups pooled over all drive levels. Figs. 8, 9, and 10 present the PDGs for the 60%, 70% and 80% groups separately. In Fig. 7 we may see that striking changes in the gradient have taken place as a function of discrimination training and these changes are mirrored at all levels of drive as the following three figures indicate. The gradients are steepened and are displaced from the S+ in a direction opposite to S- an amount inversely related to the (S+, S-) difference. The difference between the means of the three PDGs is significant ($F = 10.74$, 2/45 df, $p \angle .01$) (Table IX).

In Fig. 11 the gradients of the three different drive groups are presented, pooled for the three problems. Figs. 12, 13 and 14 present the gradients for the three problem groups separately.

Fig. 7. Post-Discrimination Generalization Gradients after Three Different Discrimination Problems, Pooled over Three Drive Levels

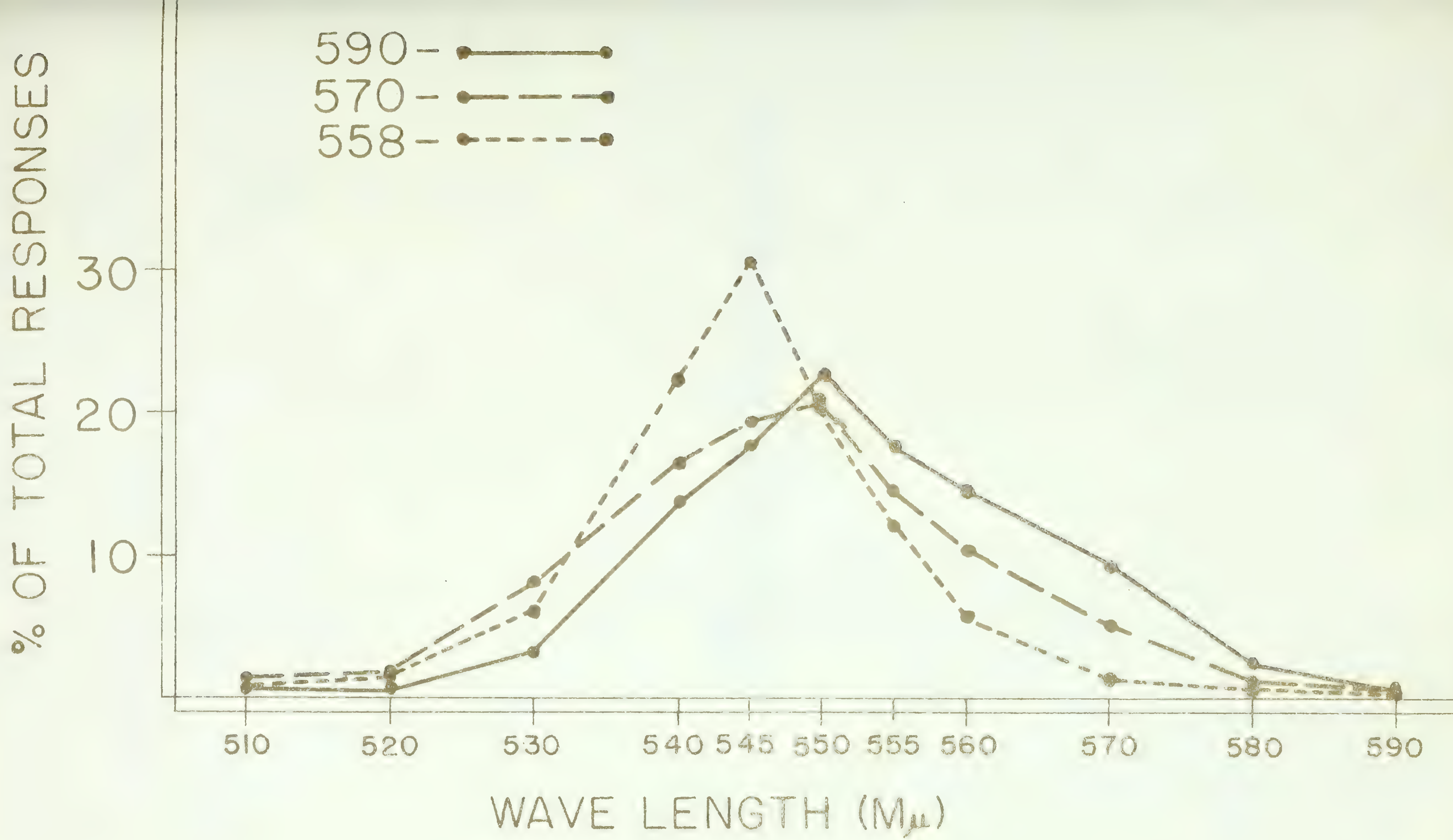

590
570
558
% OF TOTAL RESPONSES
30
20
10
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 8. Post-Discrimination Generalization Gradients of the 60% group after Three Different Discrimination Problems

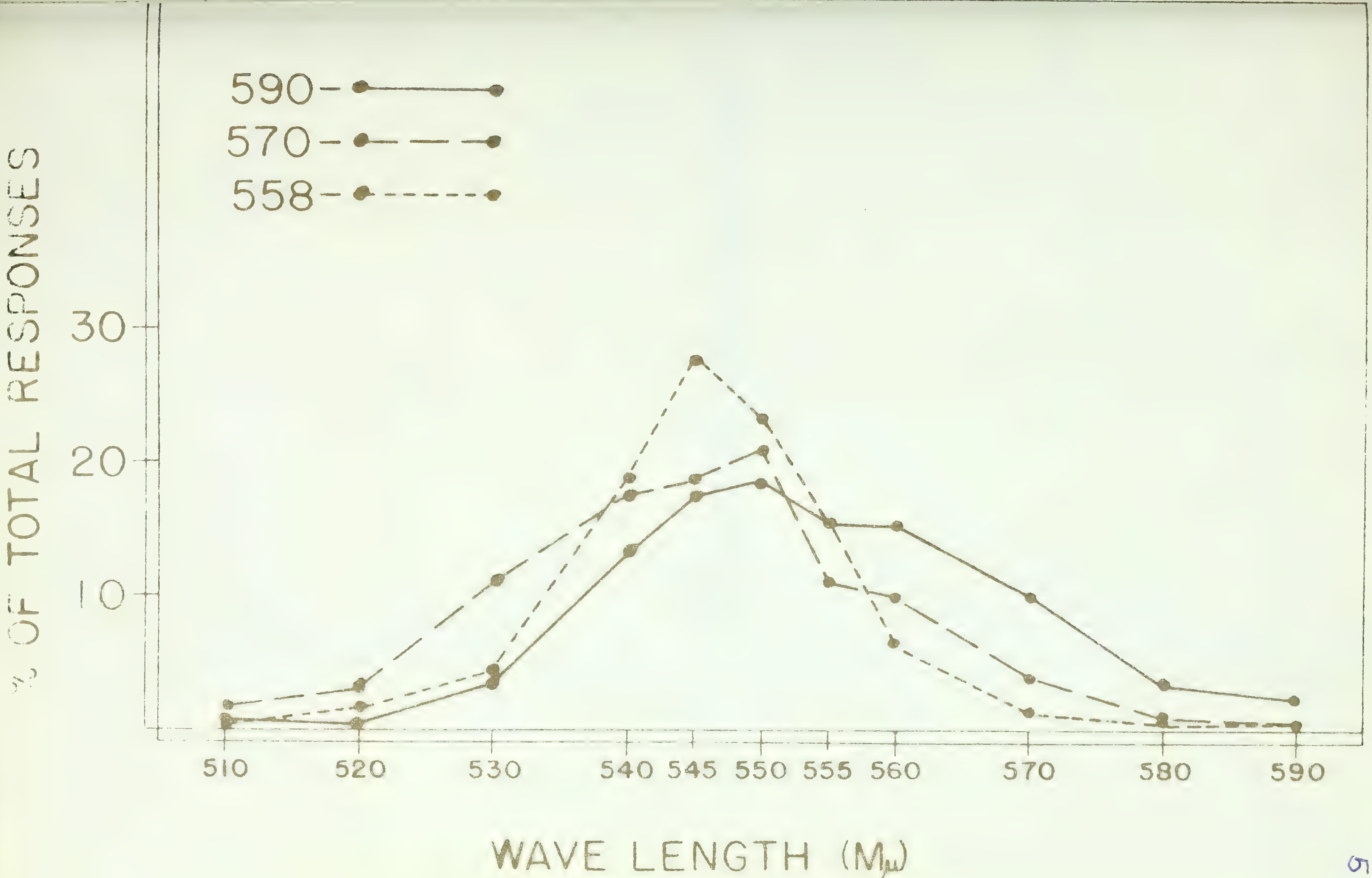

590
570
558
% OF TOTAL RESPONSES
30
20
10
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 9. Post-Discrimination Generalization Gradients of the 70% group after Three Different Discrimination Problems

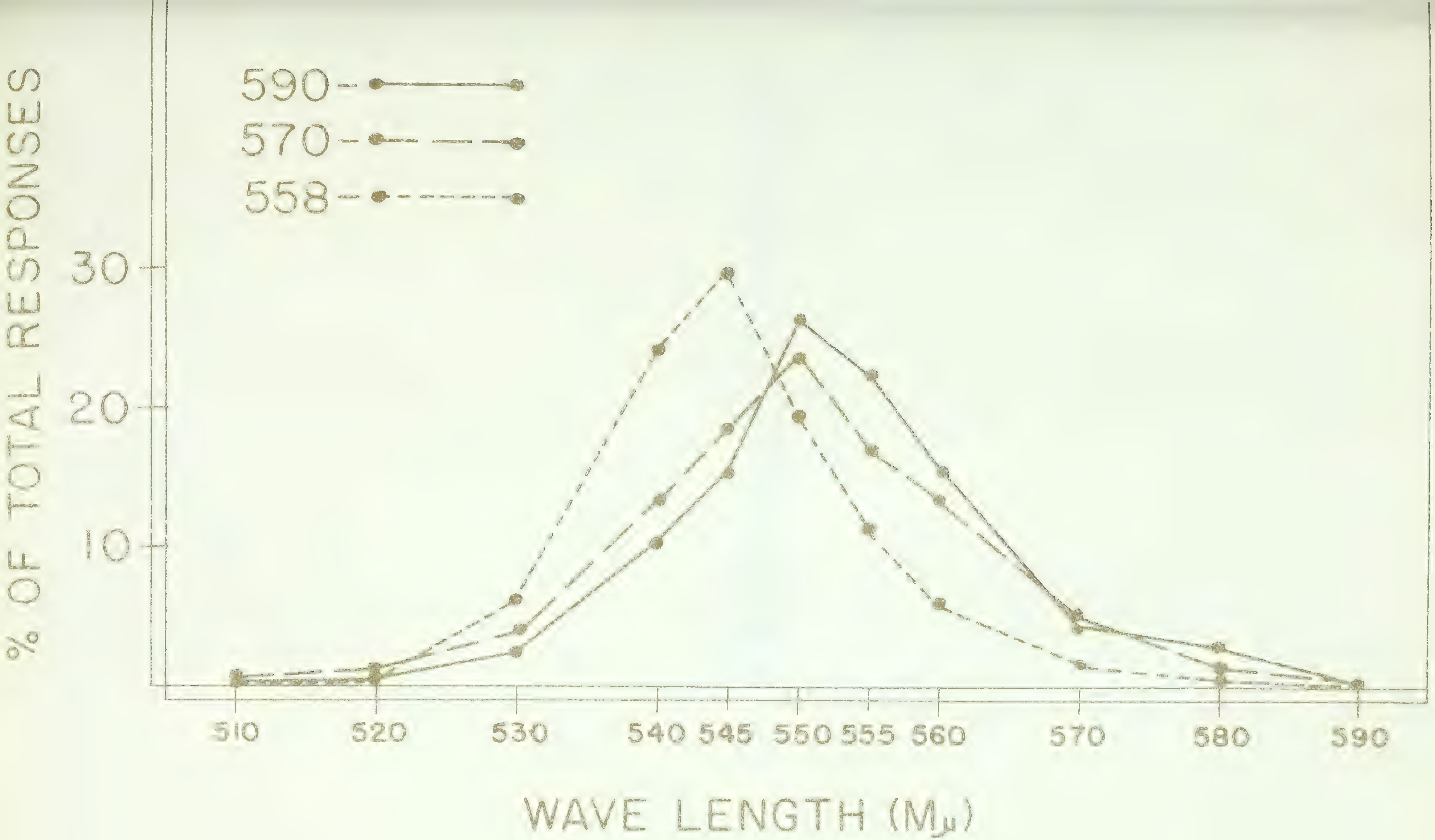

590
570
558
% OF TOTAL RESPONSES
30
20
10
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 10. Post-Discrimination Generalization Gradients of the [illegible] group after Three Different Discrimination Problems

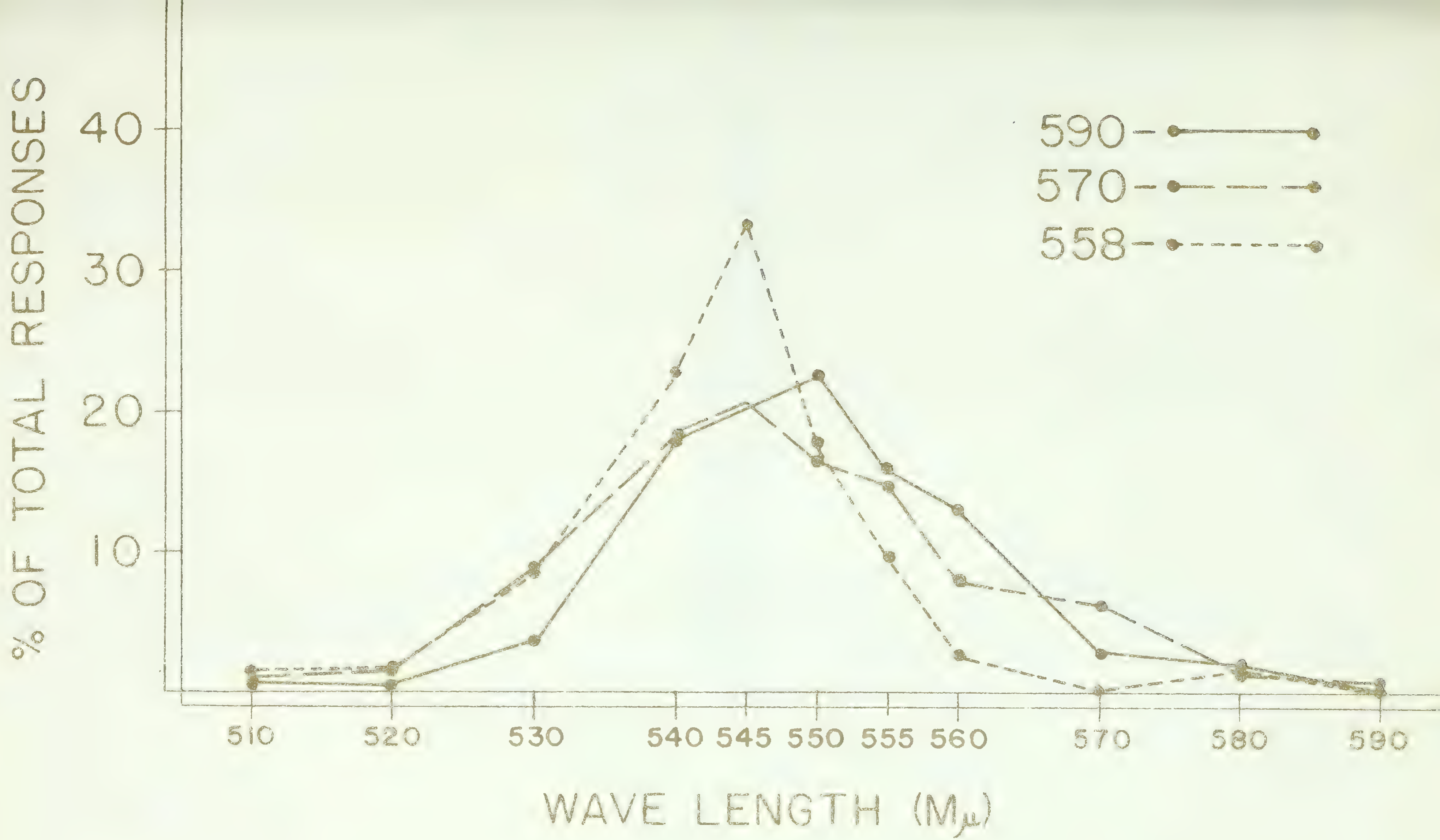

590
570
558
40
30
20
10
% OF TOTAL RESPONSES
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 11. Post-Discrimination Generalization Gradients of the Three Different Drive Groups, Pooled over Three Discrimination Problems

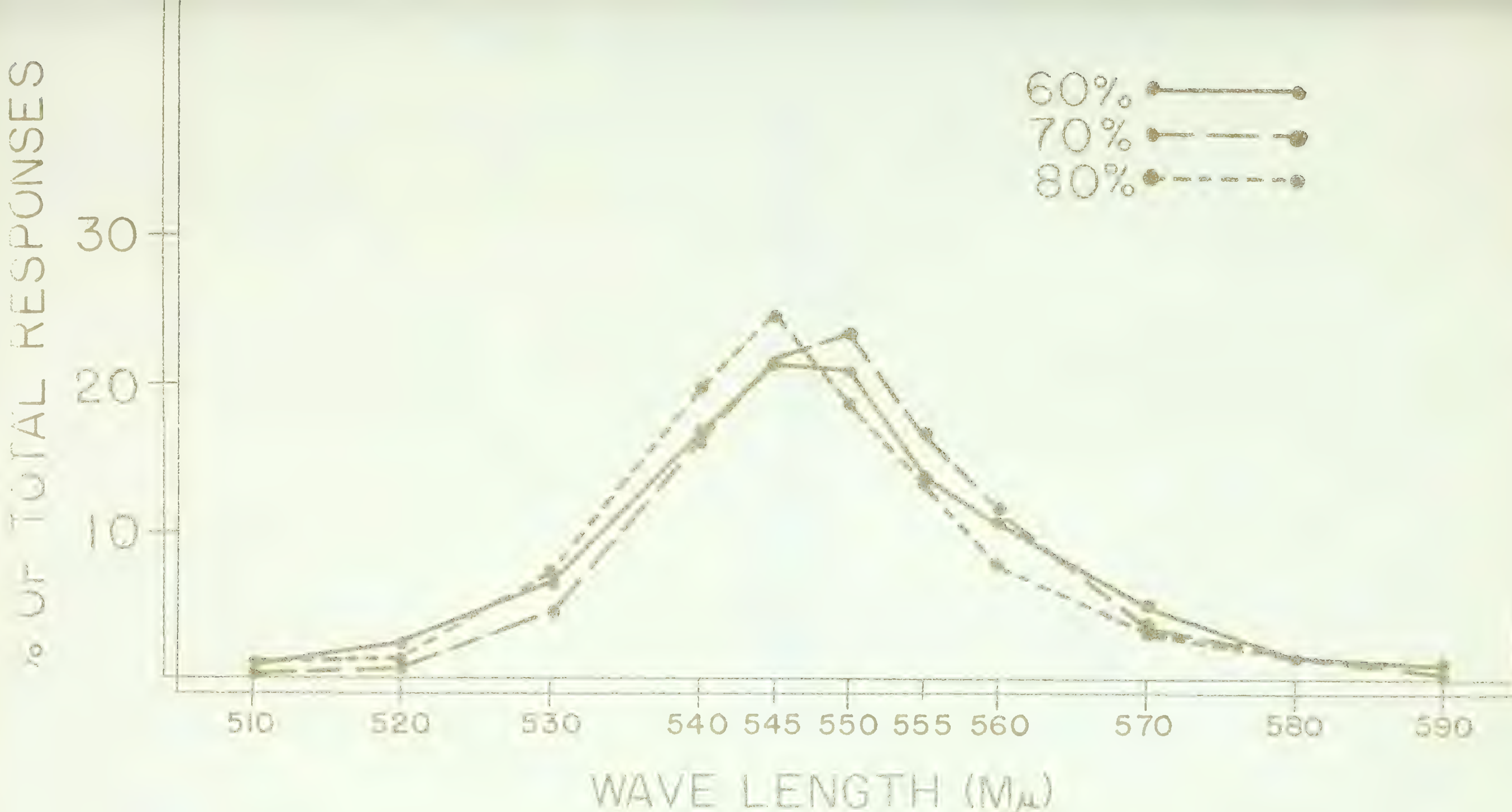

% OF TOTAL RESPONSES
30
20
10
60%
70%
80%
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 12. Post-Discrimination Generalization Gradients of the Three Different Drive Groups after Training on 550 $m\mu$ + 590 $m\mu$ -

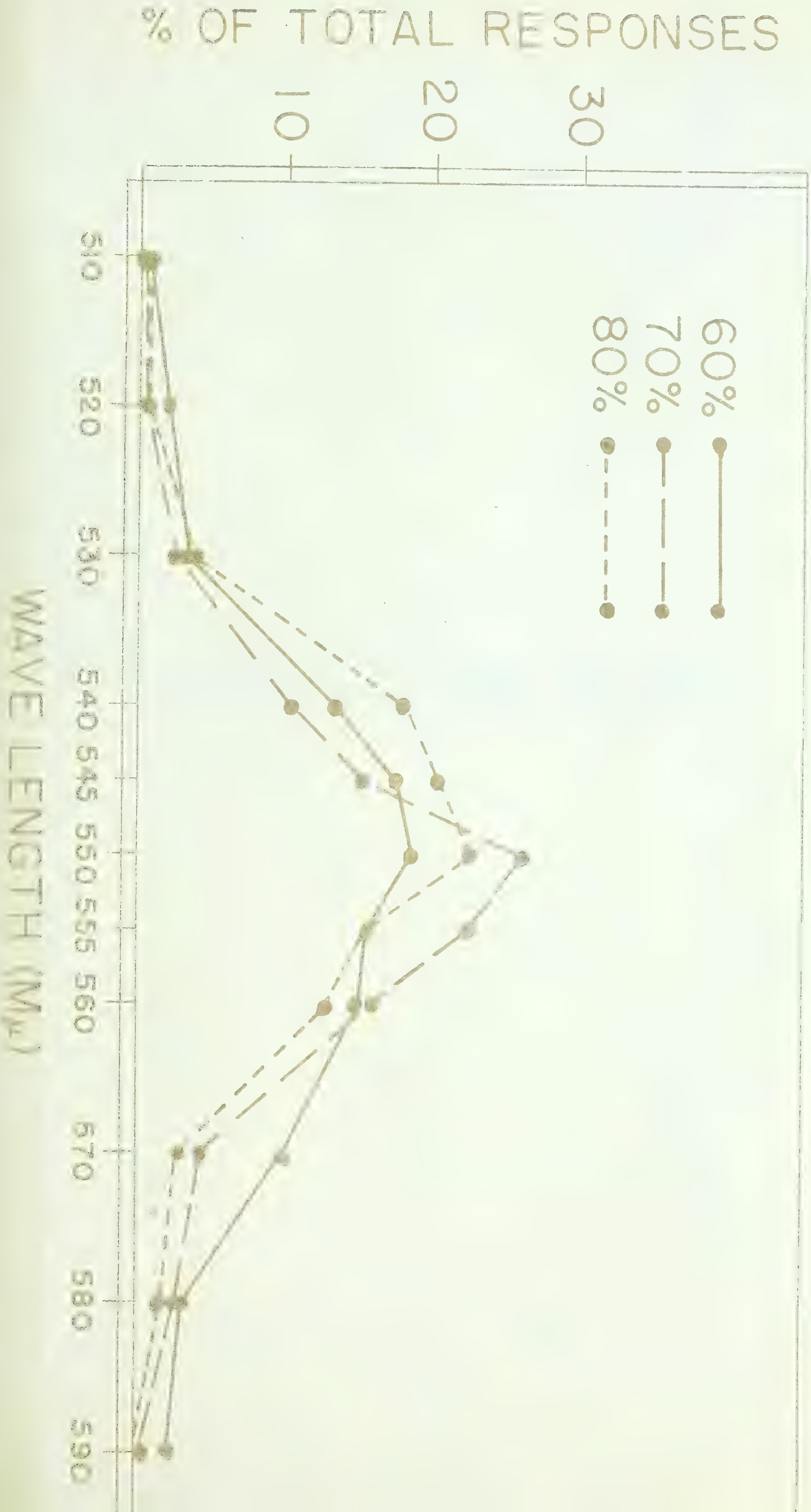

% OF TOTAL RESPONSES
10
20
30
60%
70%
80%
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 13. Post-Discrimination Generalization Gradients of the Three Different Drive Groups after Training on 550 Mμ, + 570 Mμ, -

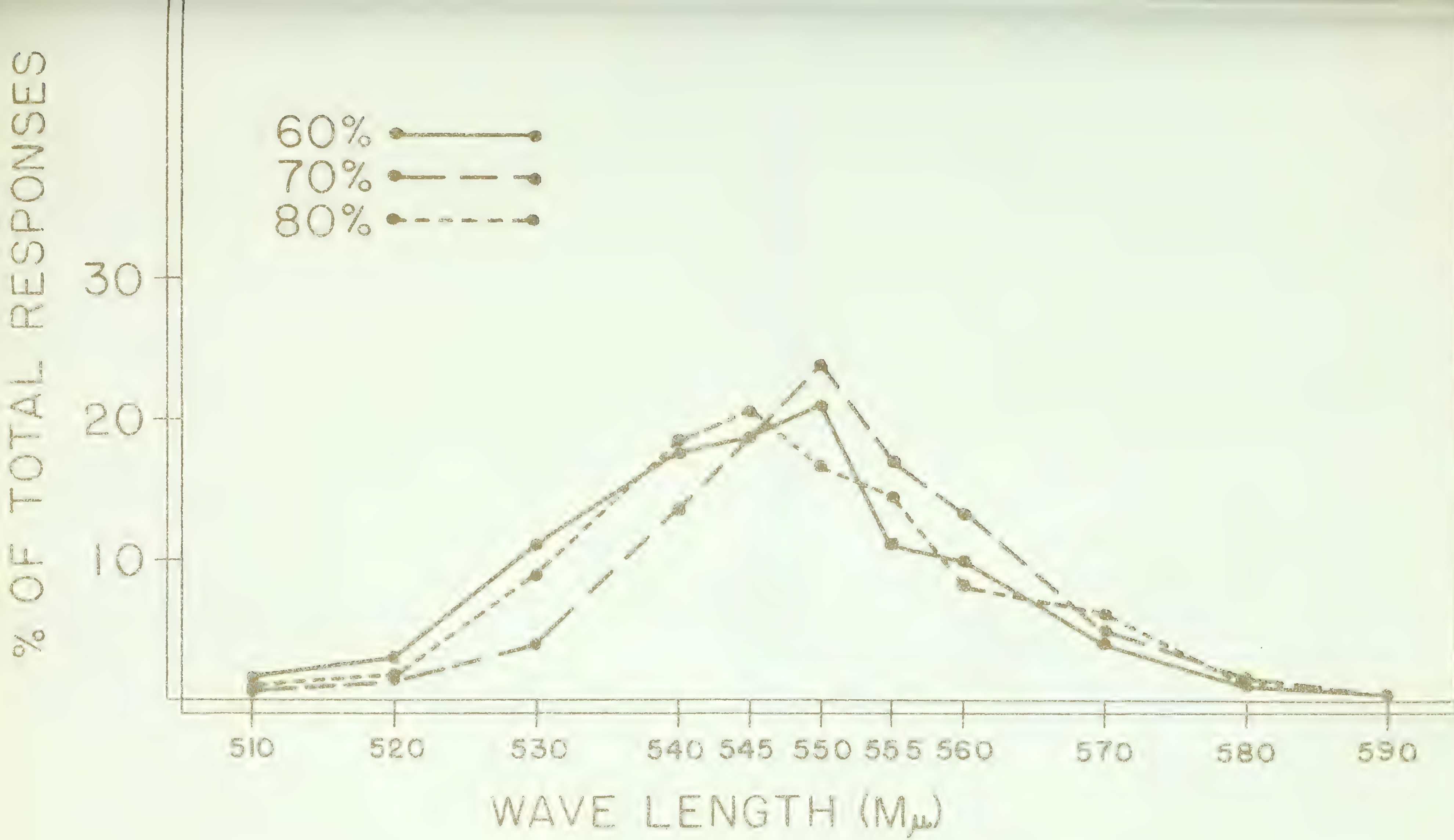

60%
70%
80%
% OF TOTAL RESPONSES
30
20
10
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Fig. 14. Post-Discrimination Generalization Gradients of the Three Different Drive Groups after Training on 550 mμ + 558 mμ −

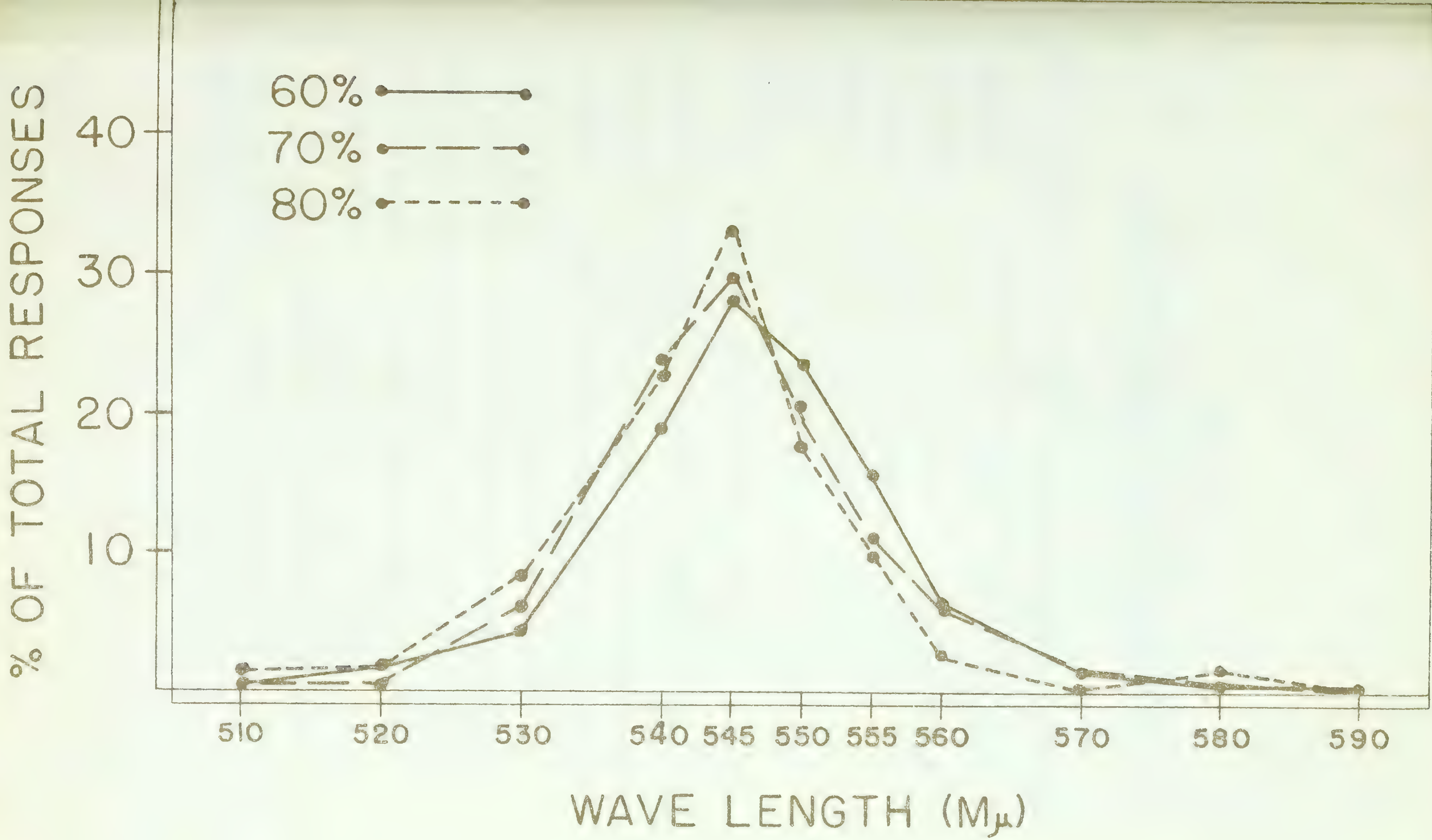

60%
70%
80%
% OF TOTAL RESPONSES
40
30
20
10
510
520
530
540
545
550
555
560
570
580
590
WAVE LENGTH (Mμ)

Table IX

ANALYSIS OF VARIANCE OF MEANS OF THE FINAL GENERALIZATION GRADIENTS AS A FUNCTION OF (S+, S–) DIFFERENCE AND DRIVE LEVEL

Source	df	MS	F	
Problems	2	128.13	10.74	$p < .01$
Drive level	2	30.58	2.56	$.05 < p < .10$
Interaction	4	12.78		
Within	45	11.93		
Total	53			

The effect of drive level on the PDGs is certainly not so striking as the effect of (S+, S–) difference. There is a suggestion that the gradient of the 80% group is displaced more than that of the other two groups ($F = 2.56$, 2/45 df, $.05 < p < .10$) (Table IX).

In this study the post-discrimination generalization gradients showed the same displacement, "steepening" and increased regularity as had been reported by Hanson (1959). In agreement with his earlier work it was shown here that the change in location of the central tendency of the PDG varies as an inverse function of the (S+, S–) difference. This effect was clearly observed with three different levels of drive.

In an earlier section it was reported that time to learn the discrimination also varied inversely with (S+, S-) difference, at all levels of drive. At this point the question may be asked "Is the change in location of the gradient a function of the (S+, S-) difference directly or is this effect mediated through the variable of the amount of discrimination training administered?" Would the PDGs of the three problem groups have differed in location if the same amount of discrimination training had been given to each? What is the effect of amount of discrimination training on the changes in the location of the PDG independent of the (S+, S-) difference?

The design of this study makes available empirical answers to these questions. The question of whether the PDGs of the different groups of Ss given equal amounts of training but on different problems (i.e. different (S+, S-) differences) differ in amount of displacement is answered by the following data. All Ss, (in all groups) which did not achieve the criterion of discrimination learning after two complete daily sessions of training were submitted to a short (three-series) generalization test. Though such a test was obtained on only one S from the 590$m\mu$ group, fourteen Ss from the 570$m\mu$ group and 16 Ss from the 550$m\mu$ group were thus tested. For each S a "displacement score" was obtained by subtracting the mean of the second generalization test

from the mean of the first. The mean of these displacement scores for the two groups was virtually identical, (5.6Mμ for the 570Mμ group vs 5.7Mμ for the 558Mμ group). This finding occurs in spite of the fact that in one case the (S+, S-) difference is more than twice what it is in the other cases. These data are presented in Table X.

The foregoing analysis was based on data from the 570Mμ group and the 558Mμ group. Another analysis may be made which involves members of the 590Mμ group. It is possible to match five Ss from the 590Mμ group with five Ss from the 570Mμ group on the basis of minutes to the learning criterion. The data for these ten Ss are presented in Table XI. The mean number of minutes to criterion is 47.4 for the 590Mμ group vs 50.2 for the 570Mμ group. The mean of the displacement scores (mean on preliminary generalization test minus mean on final generalization test) is 6.52Mμ for the 590Mμ group vs 6.00Mμ for the 570Mμ group. Thus, in agreement with the preceding analysis, Ss with the same amount of training, though on different problems with different (S+, S-) differences, show the same amount of displacement.

The fact that the amount of displacement of the central tendency of the generalization gradient varies with the amount of discrimination training administered is not surprising. If

Table X

DISPLACEMENT OF THE MEAN OF THE GENERALIZATION GRADIENT WITH TWO SESSIONS OF DISCRIMINATION TRAINING AT TWO DIFFERENT (S+, S-) VALUES

570 Group		558 Group	
S # 2	12.37 Mμ	S #15	7.91 Mμ
S # 5	2.39 Mμ	S #54	-3.11 Mμ
S #14	7.77 Mμ	S #66	4.55 Mμ
S #56	14.72 Mμ	S #51	7.90 Mμ
S #70	-0.62 Mμ	S #12	6.49 Mμ
S #46	6.59 Mμ	S #18	8.42 Mμ
S #47	7.04 Mμ	S #44	9.52 Mμ
S #59	4.77 Mμ	S #48	2.40 Mμ
S #72	-0.97 Mμ	S #60	4.25 Mμ
S #43	2.22 Mμ	S #67	7.91 Mμ
S #40	3.21 Mμ	S #32	-2.25 Mμ
S #37	0.12 Mμ	S #38	2.75 Mμ
S #31	7.82 Mμ	S #25	9.64 Mμ
S #62	10.27 Mμ	S #22	14.44 Mμ
		S #29	7.07 Mμ
Mean = 5.6 Mμ		S #68	3.37 Mμ
		Mean = 5.7 Mμ	

Table XI

DISPLACEMENT OF THE MEAN OF THE GENERALIZATION GRADIENT AS A FUNCTION OF TIME (MINUTES) TO CRITERION WITH TWO DIFFERENT SETS OF (S+, S-) VALUES

570 Group			590 Group		
	Min. to Criterion	Displacement		Min. to Criterion	Displacement
S #50	47	4.06Mμ	S # 1	45	-8.83Mμ
S #65	43	5.37Mμ	S #58	42	4.29Mμ
S #53	57	8.78Mμ	S #13	54	14.60Mμ
S #34	24	-0.56Mμ	S #49	25	12.05Mμ
S #56	80	12.36Mμ	S #20	71	10.51Mμ
	Mean = 50.2	Mean = 6.00Mμ		Mean = 47.4	Mean = 6.52Mμ

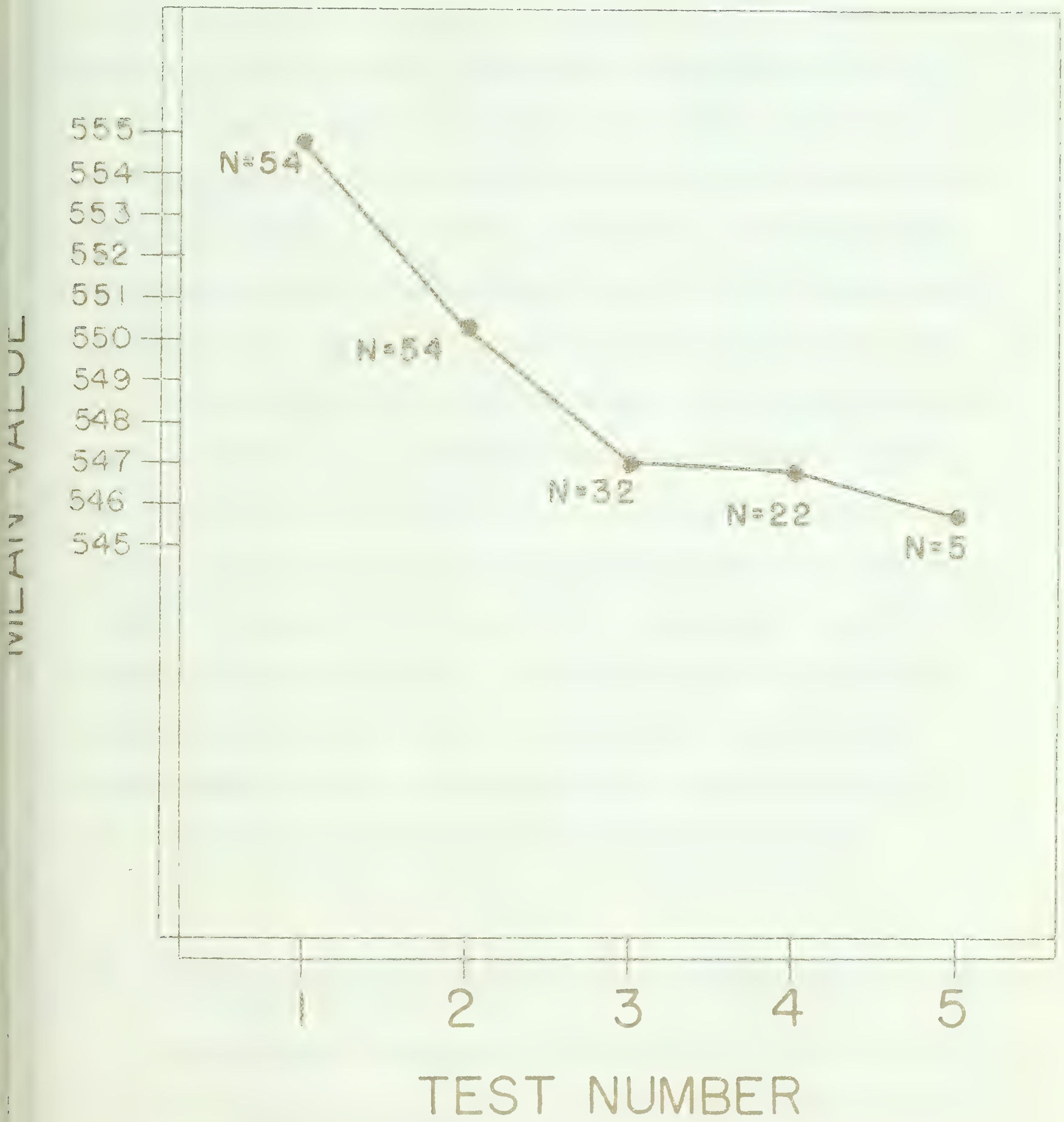
some process analogous to Spence's "gradient of inhibition" is responsible for the displacement, then more discrimination training would produce more inhibition, thus more displacement. However, as long as inhibition is assumed to be maximal at the value of the negative stimulus and decreases as the stimulus changes, then the location of S- with regard to its physical distance from S+ must be a significant variable. If, when we control for the effect of

amount of training the (S+, S-) difference loses its significance, then the kind of a subtractive mechanism hypothesized by Spence becomes less plausible.

It has been stated that amount of discrimination training appears to be the variable which determines the amount of displacement of the PDG. Next we shall consider the nature of this relationship. In Fig. 15 are plotted the means of the preliminary generalization gradients obtained from all Ss, the means of the second obtained gradient, the third, etc. We have pooled the data from all groups since it appears that neither drive level nor (S+, S-) difference seem to have any effect on the location of the PDG when amount of training is held constant. Under each of the values is recorded the number of Ss whose scores are represented in that mean value. The value of N continually decreases indicating that all Ss had at least two generalization tests whereas progressively fewer Ss had three tests, four tests etc.

The figure shows a negatively accelerated decreasing function. Even as few as two discrimination training sessions produced a substantial shift in the position of the gradient. The displacement continues to increase with further training but at a negatively accelerated pace. It is unlikely that further training would have resulted in any further changes in the location of the gradient.

Fig. 15. Mean of the Gradient as a function of Ordinal Position of Test


MEAN VALUE
555
554
553
552
551
550
549
548
547
546
545
N=54
N=54
N=32
N=22
N=5
1
2
3
4
5
TEST NUMBER

One of Hanson's most interesting findings was that occasionally an S in discrimination training will initially show a relative gain in the rate of response to S- before the effect of non-reinforcement becomes evident. This finding was confirmed here. In addition, the inclusion of a generalization test after two days of training indicates that those Ss which have shown no evidence that they have started to master the discrimination still tend to produce a displacement of the gradient. In Table XXII in the appendix it may be seen that Ss #23, 25, 47, 51, 59, 67 and 72 have shown no improvement after two days of training. Yet Table XXXIII in the appendix shows a substantial displacement of the mean of the gradients in five of the seven cases. This finding poses another problem for a Spence-type position which interprets the displacement of the gradient as a function of a hypothetical gradient of inhibition. It seems logical to assume that any inhibition which accumulates during the course of unreinforced responding to S- should reduce the rate of responding to S- as well as be reflected in a distortion of the stimulus generalization gradient.

IV. Stimulus Generalization and Subsequent Discrimination Learning.

Can the ease of formation of a discrimination be predicted from the stimulus generalization gradient? The answer to this

requires a further analysis of the data presented earlier. It was reported in an earlier section that time to criterion and number of responses to S- in discrimination training are both inversely related to (S+, S-) difference. In the case of time to criterion there was also evidence that the effect of drive level may be significant. The analysis of the effects of a third independent variable, some measure of absolute or relative generalization to the negative stimulus, requires an application of the analysis of covariance technique. This procedure enables us to test the significance of the relationship between the dependent variable (e.g. time to criterion) and the third independent variable. The hypothesis may be tested that the regression of the dependent variable on the third independent variable (called the control variable) is zero for all cells of the design. An F ratio provides a probability estimate for the acceptance or rejection of this null hypothesis.

Four such covariance analyses were carried out to test for the significance of the regression between time to criterion and number of responses to S- in the generalization test, between time to criterion and ratio of responses to S- divided by responses to the CS in the generalization test, between number of responses to S- in discrimination training and number of responses to S- on the generalization test, and finally between number of responses to S- in discrimination training and ratio of responses to S- divided by

number of responses to the CS on the generalization test. The results of these analyses are presented in Table XII.

It may be seen that contrary to expectation there is no evidence that the rate of formation of a discrimination can be predicted from either the number of responses to S- in the generalization test or the ratio of responses to S- divided by responses to the Cs. Neither can the S-/CS ratio predict the number of responses to S- during discrimination training. The only significant regression found was between number of responses to S- in training and number of responses to S- in the generalization test. The results indicate that those Ss which make the most responses to S- in the generalization test make the most responses to S- during discrimination training, yet there is no corresponding increase in the time required for mastery of the discrimination.

It is clear from these results that neither absolute nor relative generalization provides a basis for the prediction of the rate with which a discrimination may be formed. It would appear that the formation of a discrimination is a dynamic process the rate of which cannot be predicted from the prior static condition of the S with regard to the discriminanda. In other words, the generalization test provides us with a measure of the S's stimulus preferences at the time of the test; it tells us nothing about the

Table XII

TESTS OF THE HYPOTHESIS $\beta = 0$*

C_{xxw}	C_{yyw}	C_{xyw}	$F = \frac{C^2_{xyw}}{C_{xxw}C_{yyw} - C^2_{xyw}} \cdot \frac{N - 2k}{1}$
		Cross Products	
1. Responses to S- in generalization test	Time to Criterion		
69,428.8	117,119.2	21,426.3	2.15 , 1/36 df
2. Responses to S-/ Responses to 550Mu	Time to Criterion		
246,205.8	117,119.2	23,022.5	0.67 , 1/36 df
3. Responses to S- in generalization test	Responses to S- in discrimination training		
69,428.8	26,245,179.9	492,851.0	5.54 , 1/36 df $p < .05$
4. Responses to S-/ Responses to 550Mu	Responses to S- in discrimination training		
246,205.8	26,245,179.9	288,734.0	0.47 , 1/36 df

*Walker and Lev, Statistical Inference, New York, Henry Holt and Co., 1953.

rate at which such preferences may change through learning.

These conclusions are based on a negative finding and therefore are subject to the limitations that acceptance of the null hypothesis necessitates. Whether or not the use of a larger sample or a different experimental procedure would have demonstrated an effect where we were unable to do so, it is impossible to say. We can say, however, that if a relationship between rate of discrimination learning and some measure of generalized response strength to the negative stimulus does exist, it is not of sufficient strength to be conspicuous.

Chapter V

SUMMARY AND CONCLUSIONS

An experiment was performed in order to gather data bearing on four different problems in the area of operant generalization and discrimination. These problems concerned the influence of drive level on generalization, the influence of drive level on discrimination learning, the effect of discrimination training on subsequent stimulus generalization and the relationship between stimulus generalization and the subsequent formation of a discrimination.

Three groups of 18 pigeons each were trained to peck at a key illuminated by a monochromatic light of 550Mμ. The three groups differed in drive level, defined as the per cent of original ad lib. weight. One group each was run at 60%, 70% and 80%. All groups

were given five days of training under a variable interval reinforcement schedule with a mean interval of one minute. Next a generalization test in extinction was administered to all Ss. The test consisted of random presentations of wave-lengths varying from 510Mμ to 590Mμ. After the completion of the generalization test the three drive level groups were further sub-divided into three discrimination problem groups, 550Mμ + 590Mμ -, 550Mμ + 570Mμ -, and 550Mμ + 558Mμ -, thus completing a three by three factorial design with six Ss per cell. During the course of discrimination training responding to the S+ was rewarded according to the same VI schedule previously used while responding to the negative stimulus was never reinforced. Also, during the course of discrimination training, after the completion of every even numbered day of training, (days 2, 4, 6 etc.) a short generalization test was given to all Ss. After the criterion of discrimination learning was met, all Ss were subjected to a final generalization test.

The following were the major findings of this study: Generalization and Motivation. Under the conditions of the present experiment, the level of motivation of the Ss had no reliable effect on VI rate during training, number of responses in the preliminary generalization test under extinction conditions, or the "steepness" of the generalization gradient. A number of

possible reasons for the discrepancy between this and other studies was offered.

Discrimination Learning and Motivation. Four different measures of discrimination learning were employed: (a) time to the criterion of learning, (b) time to one half the total number of responses to S during discrimination training, (c) number of responses to S during discrimination training and (d) per cent of the total number of responses given to S during training. Three different discrimination problems were used in order to create a range of difficulty. The three problems, 550Mμ + 590Mμ −, 550Mμ + 570Mμ − and 550Mμ + 558Mμ − produced reliable differences in ease of learning according to all four measures. The variance attributable to drive level approached significance ($.05 < p < .10$) with the two time measures but lacked significance with the two response strength measures. With the response strength measures there appeared to be an interaction between the effects of (S+, S−) difference and drive level. However, the interaction was not of the type predicted by the "Yerkes-Dodson Hypothesis". In the present case, with the most difficult problem the highest drive level was optimal, with the problem of moderate difficulty, the lowest drive level was best, whereas with the easiest problem the moderate level of drive provided the most favorable condition for learning.

Discrimination Training and Subsequent Stimulus Generalization.

In agreement with an earlier study by Hanson (1959) it was shown that following discrimination training the generalization gradient is "steeper" and more regular and the central tendency of the gradient is displaced from the S+ to a value farther removed from the S-. Also in agreement with Hanson the extent of the shift was an inverse function of the (S+, S-) difference. Whereas Hanson analyzed the location of the mode of the gradient, in the present study the measure of central tendency used was the mean. This measure does not require extrapolation from known values (as does the mode) and yet is more sensitive to extreme values than is the median.

The procedure of obtaining a control gradient from each S before the start of discrimination training made it possible to focus more clearly on the variables which determine the displacement of the central tendency of the gradient. It was shown that when the amount of discrimination training is held constant, the (S+, S-) difference has no effect on the amount of displacement. This suggests that amount of discrimination training is the vehicle through which the (S+, S-) difference has its effect on the location of the PDG. This finding seems contradictory to a Spence-type analysis of discrimination learning in the free operant situation.

It was also shown that with (S+, S-) difference held constant, displacement of the central tendency of the gradient is an increasingly negatively accelerated function of amount of discrimination training. It was found that the shift in the location of the gradient begins to take place even before there is any evidence that learning of the discrimination has begun, and the problem that this fact presents to a Spence-type analysis of the present learning situation was indicated.

Stimulus Generalization and Subsequent Discrimination Learning. Two different measures of stimulus generalization, number of responses to S- on the preliminary generalization test and ratio of responses to S- divided by responses to the CS were used in an attempt to predict the ease of formation of a discrimination. Two different dependent variables were employed, the number of responses to S- during the course of discrimination training and the number of minutes of training to criterion. It was found that neither of the two independent variables was significantly related to the rate of formation of the discrimination. A significant positive relationship was established, however, between number of responses to S- in the generalization test and number of responses to S- in subsequent discrimination training. In other words, those Ss which make the most responses to S- in the generalization test make the most responses to S- in discrimination training, yet

there is no corresponding increase in the time required for mastery of the discrimination. These findings suggest that the formation of a discrimination is a dynamic process, the rate of which cannot be predicted from the prior static condition of the <u>S</u> with regard to the discriminanda.

APPENDIX

Table XIII

NUMBER OF RESPONSES IN VARIABLE INTERVAL REINFORCEMENT
60% GROUP

	Day 1	Day 2	Day 3	Day 4	Day 5	Mean-Day 4 &5
S#55	556	708	1280	1115	1012	1064
S#49	407	603	605	600	704	652
S#69	563	382	506	1207	795	1002
S#74	504	809	806	655	702	679
S# 1	1011	1654	1820	1403	1632	1518
S#58	670	1021	804	903	609	756
S# 2	654	680	421	900	580	740
S# 5	857	833	628	620	803	712
S#14	273	713	807	1507	1520	1514
S#56	636	1066	1081	1218	918	1068
S#70	1003	697	895	840	1008	924
S#50	816	670	574	603	797	700
S# 6	376	508	705	756	878	817
S#15	908	700	604	990	878	934
S#54	950	722	1101	1002	1198	1100
S#51	1066	800	1256	928	1300	1114
S#63	1581	1503	1600	1708	1812	1760
S#66	1200	985	1061	1156	994	1075
Mean	779.5	836.3	919.4	1006.2	1007.8	1007.2

Table XIV

NUMBER OF RESPONSES IN VARIABLE INTERVAL REINFORCEMENT
70% GROUP

	Day 1	Day 2	Day 3	Day 4	Day 5	Mean-Day 4 & 5
S#36	1206	834	1308	1500	1709	1605
S#45	589	750	908	599	850	725
S#42	550	1041	1300	973	798	888
S#39	756	658	502	750	800	775
S#16	468	610	821	875	1404	1139
S#13	850	366	887	550	501	526
S#72	903	1205	1600	1686	1763	1726
S#59	503	907	900	984	1301	1141
S#65	850	485	508	921	940	931
S#47	508	850	826	722	900	811
S#53	1203	1107	900	1323	1177	1250
S#46	460	1015	908	1103	1297	1200
S#48	906	900	1009	1207	1293	1250
S#67	512	650	673	740	613	677
S#60	920	1303	1480	1088	1350	1219
S#44	1523	1568	1404	1425	1625	1575
S#18	892	733	700	1102	971	1037
S#12	589	408	530	508	570	539
Mean	788.2	855.0	953.5	1003.1	1103.4	1056.3

Table XV

NUMBER OF RESPONSES IN VARIABLE INTERVAL REINFORCEMENT
80% GROUP

	Day 1	Day 2	Day 3	Day 4	Day 5	Mean-Day 4 & 5
S#20	530	600	1202	1094	896	995
S#23	630	1011	708	1766	1360	1563
S#26	256	280	956	481	619	550
S#30	937	408	401	426	750	585
S#33	400	703	324	750	640	695
S#52	816	708	506	953	998	975
S#31	1360	1308	1276	1400	1399	1400
S#34	520	400	407	608	750	679
S#37	904	2050	508	2200	2410	2305
S#40	933	1125	1073	1308	1270	1289
S#43	1030	650	1108	1074	1332	1203
S#62	1006	1256	1250	1003	897	950
S#22	696	307	738	859	1040	950
S#25	308	1200	1136	1008	1208	1108
S#29	380	555	808	850	1101	975
S#32	553	746	625	1403	1065	1234
S#38	408	406	440	653	851	752
S#68	609	503	904	904	958	932
Mean	682.0	789.8	801.7	1041.1	1085.8	1063.3

Table XVI

PRELIMINARY GENERALIZATION GRADIENTS (NUMBER OF RESPONSES)
60% GROUP

	WAVE LENGTH (mμ)										
	510	520	530	540	545	550	555	560	570	580	590	Total
S# 1	14	17	18	18	14	24	86	17	4	16	18	246
S#15	15	41	10	20	35	59	60	51	28	29	38	386
S# 2	0	0	0	4	5	11	10	15	5	1	11	62
S# 5	0	0	7	6	18	21	26	24	14	8	9	133
S# 6	0	0	13	67	75	54	24	2	0	7	0	242
S#14	34	42	58	110	105	120	176	243	109	103	62	1162
S#49	0	0	1	16	29	33	36	40	29	26	10	220
S#55	26	8	40	45	65	79	94	88	86	56	57	644
S#66	0	0	3	7	12	31	32	28	43	13	3	172
S#70	38	32	38	46	62	70	87	53	58	66	47	597
S#56	25	17	30	26	34	42	32	42	34	31	23	336
S#54	25	33	37	63	93	54	75	41	11	1	3	436
S#51	1	0	0	1	1	38	84	99	39	40	27	330
S#50	22	28	12	27	40	28	39	36	23	9	12	276
S#58	15	22	12	29	32	23	46	34	16	28	25	282
S#63	10	12	44	78	138	158	163	166	103	57	19	948
S#69	1	10	8	13	12	49	47	31	38	54	35	298
S#74	6	19	24	32	27	41	54	81	62	56	84	486
Mean	12.9	15.6	19.7	33.8	44.3	51.9	65.1	60.6	39.0	23.4	26.8	403.1

Table XVII

PRELIMINARY GENERALIZATION GRADIENTS (NUMBER OF RESPONSES)
70% GROUP

	WAVE LENGTH (mμ)											
	510	520	530	540	545	550	555	560	570	580	590	Total
S#12	0	12	5	37	24	32	33	17	10	25	1	196
S#18	18	9	18	57	46	47	53	97	54	24	6	429
S#13	0	1	0	6	6	8	21	14	14	12	34	116
S#16	0	0	4	11	52	74	62	24	19	13	0	259
S#42	5	5	19	36	24	37	39	39	22	15	23	264
S#44	3	2	7	14	39	52	38	31	43	27	11	267
S#36	8	7	48	93	74	76	97	69	81	63	26	642
S#39	22	5	13	56	26	24	29	19	52	16	5	267
S#46	3	5	20	56	44	31	45	44	69	38	46	401
S#45	0	0	0	9	20	48	57	62	20	1	2	214
S#60	0	2	0	11	17	24	33	33	20	19	11	170
S#67	1	7	15	22	50	54	54	74	55	43	13	388
S#72	39	42	45	88	89	67	72	86	115	115	94	852
S#65	0	0	7	6	17	16	33	28	27	11	4	149
S#47	0	0	17	32	54	34	45	62	46	15	22	327
S#53	18	0	21	4	27	52	26	46	39	30	29	292
S#48	1	3	27	21	48	57	36	58	37	40	25	353
S#59	10	1	22	38	84	85	130	156	175	108	99	908
Mean	7.1	5.6	16.0	33.2	41.2	45.4	50.2	53.4	49.9	34.1	25.5	360.8

Table XVIII

PRELIMINARY GENERALIZATION GRADIENTS (NUMBER OF RESPONSES)
80% GROUP

	WAVE LENGTH (mμ)											
	510	520	530	540	545	550	555	560	570	580	590	Total
S#20	10	3	17	34	42	59	85	90	85	64	34	529
S#22	5	10	6	7	3	35	38	15	45	25	15	204
S#23	51	36	38	45	56	67	59	46	46	12	15	471
S#25	1	17	0	4	7	24	15	23	36	24	4	155
S#26	0	4	7	13	16	31	41	49	6	7	1	171
S#31	15	20	40	124	102	103	139	112	110	121	89	975
S#32	2	17	66	92	90	89	86	97	25	20	0	[illegible]
S#33	0	0	8	23	38	59	32	32	34	6	1	248
S#29	12	6	42	43	40	94	57	47	52	17	14	422
S#37	32	28	99	94	166	240	202	176	147	116	66	1360
S#40	57	64	74	60	81	125	80	[illegible]	90	55	17	791
S#30	2	0	8	24	39	54	45	42	25	34	12	285
S#34	8	6	2	15	25	20	24	19	22	11	4	156
S#36	5	9	17	50	62	48	56	39	12	16	11	325
S#43	29	28	39	59	49	40	45	40	28	26	18	401
S#52	6	13	43	19	22	22	26	22	31	23	35	282
S#62	4	4	11	31	62	57	61	60	59	39	39	467
S#68	3	3	4	4	17	15	9	6	2	0	0	67
Mean	13.3	14.9	29.0	41.2	51.3	65.7	62.2	57.7	47.4	34.2	20.9	437.9

Table XIX

PRELIMINARY GENERALIZATION GRADIENTS (PER CENT OF TOTAL RESPONSES)
60% GROUP

	WAVE LENGTH (Mμ)										
	510	520	530	540	545	550	555	560	570	580	590
S# 1	6	7	7	7	6	10	35	7	2	7	7
S# 2	0	0	0	7	8	18	16	25	8	2	18
S# 5	0	0	5	5	14	16	20	18	11	6	7
S# 6	0	0	5	28	31	22	10	1	0	3	0
S#14	3	4	5	9	9	10	15	21	9	9	5
S#15	4	11	3	5	9	15	16	13	7	8	10
S#55	4	1	6	7	10	12	15	14	13	9	9
S#49	0	0	0	7	13	15	16	18	13	12	5
S#54	6	8	8	14	21	12	17	9	3	0	1
S#56	7	5	9	8	10	13	10	13	10	9	7
S#70	6	5	6	8	10	12	15	9	10	11	8
S#66	0	0	2	4	7	18	18	16	25	8	2
S#50	8	10	4	10	14	10	14	13	8	3	4
S#51	0	0	0	0	0	12	25	30	12	8	8
S#58	5	8	4	10	11	8	16	12	6	10	9
S#63	1	1	5	8	15	17	17	18	11	6	2
S#69	0	3	3	4	4	16	16	10	13	18	12
S#74	1	4	5	7	6	8	11	17	13	12	17
Mean	2.8	3.7	4.3	8.2	11.0	13.6	16.8	14.1	9.7	7.8	7.3

Table XX

PRELIMINARY GENERALIZATION GRADIENTS (PER CENT OF TOTAL RESPONSES)
70% GROUP

	WAVE LENGTH (Mμ)										
	510	520	530	540	545	550	555	560	570	580	590
S#12	0	6	3	14	12	16	17	9	5	13	1
S#13	0	1	0	5	5	7	18	12	12	10	29
S#16	0	0	2	4	20	29	24	9	7	5	0
S#18	4	2	4	13	11	11	12	23	13	6	1
S#36	1	1	7	14	12	12	15	11	13	10	4
S#39	8	2	5	21	10	9	11	7	19	6	2
S#42	2	2	7	14	9	14	15	15	8	6	9
S#44	1	1	3	5	15	19	14	12	16	10	4
S#46	1	4	7	14	11	13	11	11	12	9	6
S#59	1	0	2	4	9	9	14	17	19	12	11
S#48	0	1	8	6	14	16	10	16	10	11	7
S#53	6	0	7	1	9	18	9	16	13	10	10
S#47	0	0	5	10	17	10	14	19	14	5	7
S#65	0	0	5	4	11	11	22	19	18	7	3
S#67	0	2	4	6	13	14	14	20	14	11	3
S#60	0	1	0	6	10	14	19	19	12	11	6
S#72	5	5	5	10	10	18	8	10	13	13	11
S#45	0	0	0	4	9	22	27	27	9	0	1
Mean	1.6	1.6	4.1	8.6	11.5	14.0	15.2	15.1	12.6	8.6	6.4

Table XXI

PRELIMINARY GENERALIZATION GRADIENTS (PER CENT OF TOTAL RESPONSES)
80% GROUP

	WAVE LENGTH (mμ)										
	510	520	530	540	545	550	555	560	570	580	590
S#20	2	1	3	6	9	11	16	17	16	12	6
S#22	2	5	3	3	1	17	19	7	22	12	7
S#23	11	8	8	10	12	14	13	10	10	3	3
S#25	1	11	0	3	5	15	10	15	23	15	3
S#26	0	2	4	8	9	18	24	26	4	4	1
S#29	3	1	10	10	9	22	14	11	12	4	3
S#30	1	0	3	8	14	19	16	15	9	12	4
S#31	2	2	4	13	10	11	14	11	11	12	9
S#32	0	3	12	16	15	15	15	17	4	3	0
S#33	0	0	3	9	15	22	13	21	14	2	0
S#34	5	4	1	10	16	13	15	12	14	7	3
S#37	2	2	7	7	12	18	15	13	11	8	5
S#38	2	3	5	15	19	15	17	12	4	5	3
S#40	7	8	9	8	10	16	10	11	11	7	2
S#43	7	7	10	15	12	10	11	10	7	6	4
S#52	2	5	16	7	8	8	10	8	12	9	13
S#62	1	1	2	7	13	12	17	17	13	8	8
S#68	4	4	6	6	25	28	13	9	3	0	0
Mean	2.9	3.7	5.9	8.9	11.[illegible]	15.8	14.6	13.4	11.1	7.2	4.1

Table XXII

NUMBER OF RESPONSES IN DISCRIMINATION TRAINING

60% - 590 Mμ Group — Trials in blocks of 2

S#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
58	S+	65	136	194	246	357	485	603	765	933	1093										
	S-	6	12	13	15	24	30	36	42	46	46	46									
1	S+	28	150	313	663	907	1256	1503	1753	1903	2021	2227									
	S-	0	150	306	428	542	630	596	755	830	862	862									
49	S+	74	129	178	209	227	255														
	S-	4	8	8	10	10	10														
55	S+	56	134	210	289	333															
	S-	3	5	8	8	8															
74	S+	63	199	345	414	539	641	792													
	S-	18	30	32	34	38	40	40													
69	S+	100	207	312	338																
	S-	22	22	22	22																
70% - 590 Mμ Group																					
45	S+	99	182	232																	
	S-	1	1	1																	
39	S+	154	238	374	474	524	610	741	830	960	1060	1169									
	S-	12	22	22	29	36	41	45	49	56	56	56									
36	S+	147	309	434	568	697	849	1068	1172	1381	1597	1792									
	S-	54	98	125	125	129	148	192	231	231	231										
16	S+	67	118	281	333																
	S-	2	6	6	6																

Table XXII (continued)

70% - 590 Mμ Group Trials in blocks of 2

S#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
42	S+	54	124	204	260	322	397	478	554	648	736	811	913	1023							
	S-	29	54	77	99	112	117	120	123	125	128	128	128	128							
13	S+	41	113	167	215	266	301	367	399	488	507	511	518	531	533						
	S-	5	8	11	14	24	29	30	30	32	32	32	32	32	32						
60% - 590 Mμ Group																					
52	S+	74	152	228	321	401	492	556	635	780	881	980	1065	1121	1155						
	S-	16	24	30	42	54	66	70	90	105	116	121	121	121	121						
33	S+	52	112	171	238	292															
	S-	17	37	39	39	39															
30	S+	31	92	138	192	239	300	376	463												
	S-	3	16	20	20	33	45	45	45												
26	S+	44	106	151	172																
	S-	6	21	21	21																
Trials in blocks of 5																					
20	S+	0	19	19	23	84	138	169	237	324	427	502	556	669	787	921	1013	1176	1299		
	S-	18	32	32	40	48	92	134	168	168	177	207	211	211	236	264	277	277			
29	S+	75	125	301	485	651	849	1068	1245	1473	1718	2045	2387	2792	3188	3614	4149	4598	5050	5383	5567
	S-	53	104	212	457	622	822	1096	1272	1463	1764	1983	2153	2305	2395	2445	2537	2613	2621	2655	2655
60% - 570 Mμ Group																					
[illegible]	S+	63	74	129	230	247	297	356	394	414	623	793	937								
	S-	51	61	103	147	150	158	169	169	169	206	239	239								
[illegible]	S+	161	305	475	580	811	1109	1423	1732												
	S-	83	111	164	214	314	341	349	349												
50	S+	204	369	567	812	956															
	S-	14	38	67	160	162															

Table XXII (continued)

S#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
60% – 570 Mμ Group																					
70	S+	226	429	653	954	1204	1390	1679	2051	2316											
	S-	117	173	236	347	450	484	608	618	618											
14	S+	648	923	1355	1830	2527	3247	3783	4746	5514	6287	7306	7656	8393	8664						
	S-	448	605	800	1127	1512	1680	2042	2310	2539	2869	2903	2951	2964	2964						
5	S+	371	644	998	1425	2028	2435	3216	3844	4453	4962	5488	6101	6671							
	S-	172	260	350	637	830	989	1076	1106	1243	1286	1303	1343	1349							
70% – 570 Mμ Group																					
46	S+	305	533	828	1003	1273	1406	1711	2059	2369											
	S-	215	344	489	511	517	760	855	892	892											
53	S+	380	783	1139	1439	1624	1737														
	S-	179	278	335	403	403	403														
59	S+	165	281	392	496	605	722	861	945	1034	1297	1541	1795	2075	2339	2593	2848	3211			
	S-	43	101	121	202	263	304	397	470	505	610	652	737	826	833	908	912	912			
65	S+	169	390	651	921	958															
	S-	87	125	133	163	163															
47	S+	219	378	545	615	792	920	1087	1288	1444	1604	1742	1901	2095	2328	2385					
	S-	106	223	304	375	474	577	719	864	1030	1117	1154	1177	1211	1248	1248					
72	S+	241	512	688	907	1181	1513	1869	2334	2847	3229	3804	4147	4636	5137	5461	5774	5981	6223	6570	
	S-	39	178	336	492	756	857	1001	1083	1120	1258	1275	1310	1524	1604	1649	1713	1717	1837	1865	
80% – 570 Mμ Group																					
62	S+	189	343	619	994	1199	1379	1559	1741	1938	2233	2604	2858								
	S-	103	153	178	223	232	239	255	263	271	337	359	359								
37	S+	551	1030	1425	1924	2381	2982	3570	4071	4519	5030	5505	6010	6640	6890						
	S-	232	355	441	549	597	669	774	801	813	856	1092	1098	1103	1103						

Table XXII (continued)

80% - 570 Mμ Group Trials in blocks of 5

S#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
34	S+	116	288	369																	
	S-	33	37	37																	
31	S+	268	544	831	1177	1487	1820	2171	2465	2831	3228	3555	3961	4406	4920	5378					
	S-	124	260	328	434	530	590	757	808	869	921	941	959	1126	1155	1155					
40	S+	198	412	655	953	1164	1493	1823	2138	2440	2642	2810	3083	3304	3570						
	S-	72	99	144	217	254	308	376	424	463	470	488	514	547	550						
43	S+	302	519	745	1113	1438	1735	1994	2227	2445	2780	3087	3386	3709	3946	4214	4465				
	S-	126	277	346	447	503	522	536	556	560	577	580	584	625	633	635	635				
60% - 558 Mμ Group																					
6	S+	212	501	725																	
	S-	73	145	145																	
15	S+	101	213	306	399	505	574	717	880	1021	1083	1133	1194	1278	1376	1469					
	S-	68	130	152	208	231	239	275	287	291	307	308	308	358	367	367					
54	S+	171	313	515	735	921	1129	1368	1736	2136	2379	2631	2751								
	S-	81	160	264	367	415	473	534	617	634	658	686									
66	S+	357	575	811	1135	1422	1674	2079	2449	2753	3068	3389	3716	4173	4549	4900	5156	5432	5638		
	S-	287	440	585	786	904	1019	1233	1292	1407	1543	1645	1679	1962	2048	2083	2103	2170	2174		
51	S+	347	603	877	1165	1326	1558	1935	2244	2629	3050	3491									
	S-	188	292	360	569	713	814	894	940	951	987	1043	1076								
63	S+	399	753	1109	1464	1801	2173	2558	3005	3365											
	S-	331	552	676	857	962	1087	1273	1476	1476											
70% - 558 Mμ Group																					
67	S+	167	342	484	684	838	1058	1241	1477	1739	1955	2145	2336	2540	2579						
	S-	144	286	440	588	779	909	1006	1104	1180	1296	1381	1428	1473	1473						
12	S+	113	213	307	419	558	678	843	1007	1128	1247	1377	1516	1650	1700	1775					
	S-	79	128	173	232	301	343	418	443	447	466	477	518	548	548						

Table XXII (continued)

S#		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
70% - 558 mμ Group		Trials in blocks of 5																			
60	S+	264	505	814	1205	1556	1927	2338	2698	3049	3395	3706	3932	4348	4674	4834					
	S-	244	391	650	1036	1296	1528	1780	1934	2055	2275	2348	2384	2416	2443	2443					
44	S+	310	636	990	1382	1836	2277	2830	3495	4081	4640	5136	5610	6135	6757	7386	7897	8327	9094		
	S-	318	573	838	1118	1436	1627	1843	1980	2111	2424	2477	2562	2700	2764	2789	2803	2817	2817		
		Trials in blocks of 10																			
48	S+	423	836	1343	1888	2387	2788	3130	3409	3669	4307	5014	5835	6833	7144						
	S-	402	754	1128	1506	1860	2149	2500	2689	2846	3108	3338	3555	3623	3623						
18	S+	417	1220	2390	3106	3793	4360	5236	6214	7257	8457	9648	10363								
	S-	303	887	1486	2009	2339	2703	2959	3099	3234	3275	3579	3794								
80% - 558 mμ Group																					
22	S+	386	806	1249	1654	2141	2593	3210	3680	3964	4624	5168	5715	6356	6906	7153					
	S-	268	495	701	881	1008	1188	1510	1670	1687	1775	1834	1909	1922	1970	2020					
25	S+	490	1051	1612	2090	2623	3190	3844	4395	4827	5276	5671	5827								
	S-	288	741	969	1114	1309	1516	1647	1734	1812	1870	1926	1962								
		Trials in blocks of 5																			
32	S+	172	381	617	862	1135	1494	1851	2237	2577	2902	3298									
	S-	110	235	395	580	746	957	1026	1056	1083	1367	1421	1421								
29	S+	161	360	573	799	916	1192	1419	1579	1820	2009	2248	2454	2711	2951	3224	3536	3760			
	S-	151	253	429	526	601	666	773	828	876	982	1017	1071	1162	1188	1192	1255	1291			
68	S+	264	600	1027	1312	1639	1975	2286	2585	2903	3146	3371	3628								
	S-	128	273	449	558	635	721	822	852	917	978	1063	1063								
38	S+	275	478	663	862	1015	1199	1383	1583	1818	2032	2242	2477	2645	2829	2920					
	S-	211	352	476	612	691	725	799	896	998	1128	1155	1159	1197	1241	1261					

Table XXIII

MEASURES OF DISCRIMINATION LEARNING:
1-TIME TO CRITERION (MINUTES)

60% - 590Mμ Group		70% - 590Mμ Group		80% - 590Mμ Group	
S# 1	45	S#13	54	S#20	71
S#49	25	S#16	15	S#23	198
S#55	20	S#42	51	S#26	15
S#69	14	S#36	42	S#30	33
S#74	26	S#39	44	S#33	19
S#58	42	S#45	10	S#52	54
Mean	= 28.7	Mean	= 36.0	Mean	= 65.0
60% - 570Mμ Group		**70% = 570Mμ Group**		**80% - 570 Mμ Group**	
S# 2	119	S#46	88	S#34	24
S# 5	130	S#47	143	S#31	148
S#14	135	S#53	57	S#37	134
S#50	47	S#59	168	S#40	140
S#56	80	S#65	43	S#43	152
S#70	85	S#72	191	S#62	117
Mean	= 99.3	Mean	=115.0	Mean	= 119.2
60% - 558Mμ Group		**70% - 558Mμ Group**		**80% - 558Mμ Group**	
S#15	178	S#12	141	S#38	149
S# 6	29	S#18	232	S#32	112
S#63	90	S#44	180	S#25	230
S#54	111	S#48	268	S#22	291
S#66	174	S#60	144	S#29	170
S#51	113	S#67	135	S#68	119
Mean	= 115.8	Mean	= 183.3	Mean	= 178.5

Table XXIV

MEASURES OF DISCRIMINATION LEARNING:
2-TIME TO ONE-HALF THE TOTAL NUMBER
OF RESPONSES TO S-

60% - 590Mμ Group		70% - 590Mμ Group		80% - 590Mμ Group	
S# 1	18	S#13	16	S#20	28
S#49	5	S#16	7	S#23	79
S#55	5	S#42	9	S#26	5
S#69	3	S#36	9	S#30	16
S#74	5	S#39	15	S#33	9
S#58	12	S#45	2	S#52	20
Mean = 8.0		Mean = 9.7		Mean = 26.2	

60% - 570Mμ Group		70% - 570Mμ Group		80% - 570Mμ Group	
S# 2	31	S#46	28	S#34	11
S# 5	40	S#47	62	S#31	60
S#14	50	S#53	10	S#37	47
S#50	31	S#59	76	S#40	47
S#56	31	S#65	11	S#43	30
S#70	34	S#72	64	S#62	33
Mean = 36.2		Mean = 41.8		Mean = 38.0	

60% - 558Mμ Group		70% - 558Mμ Group		80% - 558Mμ Group	
S#15	34	S#12	43	S#38	56
S# 6	8	S#18	77	S#32	48
S#63	31	S#44	51	S#25	60
S#54	47	S#48	98	S#22	105
S#66	62	S#60	48	S#29	60
S#51	41	S#67	48	S#68	41
Mean = 37.2		Mean = 60.8		Mean = 61.7	

Table XXV

MEASURES OF DISCRIMINATION LEARNING:
3-NUMBER OF RESPONSES TO S-

60% - 590Mμ Group		70% - 590Mμ Group		80% - 590Mμ Group	
S# 1	862	S#13	32	S#20	277
S#49	10	S#16	6	S#23	2665
S#55	8	S#42	128	S#26	21
S#69	22	S#36	231	S#30	45
S#74	40	S#39	56	S#33	39
S#58	46	S#45	1	S#52	121
Mean = 164.7		Mean = 75.7		Mean = 528.0	

60% - 570Mμ Group		70% - 570Mμ Group		80% - 570Mμ Group	
S# 2	239	S#46	892	S#34	37
S# 5	1349	S#47	1248	S#31	1155
S#14	2964	S#53	403	S#37	1103
S#50	162	S#59	912	S#40	550
S#56	349	S#65	163	S#43	635
S#70	618	S#72	1865	S#62	359
Mean = 946.8		Mean = 913.8		Mean = 639.8	

60% - 558Mμ Group		70% - 558Mμ Group		80% - 558Mμ Group	
S#15	367	S#12	548	S#38	1261
S# 6	145	S#18	3794	S#32	1421
S#63	1476	S#44	2817	S#25	1962
S#54	686	S#48	3623	S#22	2020
S#66	2174	S#60	2443	S#29	1291
S#51	1076	S#67	1473	S#68	1063
Mean = 987.3		Mean =2449.7		Mean =1503.0	

Table XXVI

MEASURES OF DISCRIMINATION LEARNING:
4-PER CENT OF TOTAL RESPONSES TO S-

60% - 590Mμ Group		70% - 590Mμ Group		80% - 590Mμ Group	
S# 1	27.91	S#13	5.66	S#20	17.58
S#49	2.65	S#16	1.77	S#23	32.29
S#55	2.35	S#42	11.12	S#26	10.88
S#69	6.11	S#36	11.42	S#30	8.86
S#74	4.81	S#39	4.57	S#33	11.78
S#58	4.04	S#45	0.43	S#52	9.48
Mean	= 7.9	Mean	= 5.8	Mean	= 15.2
60% - 570Mμ Group		**70% - 570Mμ Group**		**80% - 570Mμ Group**	
S# 2	20.33	S#46	27.35	S#34	9.11
S# 5	16.82	S#47	34.35	S#31	17.68
S#14	25.49	S#53	18.83	S#37	13.80
S#50	14.49	S#59	22.12	S#40	13.35
S#56	16.73	S#65	14.54	S#43	12.45
S#70	21.06	S#72	22.11	S#62	11.16
Mean	= 19.2	Mean	= 23.2	Mean	= 12.9
60% - 558Mμ Group		**70% - 558Mμ Group**		**80% - 558Mμ Group**	
S#15	19.99	S#12	23.59	S#38	30.10
S# 6	16.66	S#18	26.80	S#32	30.11
S#63	30.49	S#44	23.65	S#25	25.19
S#54	19.96	S#48	33.65	S#22	22.02
S#66	27.83	S#60	33.57	S#29	25.56
S#51	23.56	S#67	36.35	S#68	22.66
Mean	= 23.1	Mean	= 29.6	Mean	= 25.9

Table XXVII

POST-DISCRIMINATION GENERALIZATION GRADIENTS
(NUMBER OF RESPONSES)
60% GROUP

WAVE LENGTH (Mμ) - 590Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S# 1	6	0	4	16	30	59	27	63	26	20	36	297
S#55	0	0	0	29	67	105	115	115	105	24	0	560
S#49	3	0	19	71	107	91	46	20	11	1	0	369
S#58	2	5	43	116	107	116	94	84	27	1	0	595
S#69	0	0	14	42	44	33	31	25	25	6	2	223
S#74	21	7	14	104	106	126	189	166	114	41	5	893
Mean	5.3	2.0	15.7	63.0	76.8	88.33	83.7	78.8	51.3	15.5	7.2	489.5
WAVE LENGTH (Mμ) - 570Mμ GROUP												
S# 2	0	2	25	22	32	59	2	21	7	0	0	171
S# 5	16	24	58	322	264	215	268	150	55	37	20	1439
S#14	1	31	99	168	138	239	109	134	44	0	6	976
S#50	8	3	125	136	159	126	52	15	22	1	0	647
S#56	77	95	136	162	138	138	64	66	18	1	1	899
S#70	0	5	12	96	145	123	135	101	40	21	6	684
Mean	17.0	26.7	75.8	151.0	146.0	150.0	105.0	81.2	31.0	10.0	5.5	802.7
WAVE LENGTH (Mμ) - 558Mμ GROUP												
S#15	0	0	16	101	117	131	26	13	1	0	2	400
S# 6	0	0	4	39	148	164	135	74	16	6	1	600
S#63	2	18	69	233	242	231	138	7	0	0	1	941
S#54	11	5	32	176	192	156	108	58	3	0	0	741
S#66	8	41	33	78	184	81	88	49	17	0	10	589
S#51	2	1	45	226	346	219	178	80	6	0	14	1117
Mean	3.8	10.8	33.2	142.2	204.8	163.7	112.1	46.8	7.2	1.0	44.7	731.3

Table XXVIII

POST-DISCRIMINATION GENERALIZATION GRADIENTS
(NUMBER OF RESPONSES)
70% GROUP

WAVE LENGTH (Mμ) - 590Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S#16	0	0	0	8	19	53	49	30	9	1	0	169
S#13	0	0	1	48	56	96	63	77	28	18	1	388
S#42	3	12	15	93	98	141	83	85	20	6	0	560
S#45	0	0	0	5	45	53	74	34	4	0	0	215
S#36	0	5	81	131	112	168	171	124	43	2	0	837
S#39	5	2	11	39	50	101	57	34	15	4	4	322
Mean	1.3	3.2	18.0	54.0	63.3	102.0	82.8	64.0	19.8	5.2	0.8	415.2

WAVE LENGTH (Mμ) - 570Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S#46	0	1	8	67	70	85	26	28	18	2	1	306
S#47	0	7	6	33	77	141	139	127	60	14	3	607
S#65	1	0	1	25	31	57	63	28	11	8	0	225
S#53	0	3	1	39	53	56	36	29	0	0	0	211
S#59	5	9	22	36	72	69	50	52	12	1	2	330
S#72	30	33	185	185	221	282	198	137	76	36	11	1394
Mean	6.0	8.8	37.2	64.2	87.3	115.0	85.3	66.8	29.5	10.2	2.8	512.2

WAVE LENGTH (Mμ) - 558Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S#18	0	0	13	56	86	21	1	0	0	0	0	177
S#12	1	5	20	59	114	84	67	25	4	1	0	380
S#60	0	1	20	58	78	111	87	32	10	0	1	388
S#67	6	8	52	116	104	84	47	21	4	1	1	444
S#44	0	1	24	220	208	72	31	1	8	0	0	565
S#48	3	3	21	86	76	105	55	77	24	16	0	492
Mean	1.7	3.0	25.0	97.5	111.0	79.5	48.0	26.0	8.3	3.0	0.3	407.7

Table XXIX

POST-DISCRIMINATION GENERALIZATION GRADIENTS
(NUMBER OF RESPONSES)
80% GROUP

WAVE LENGTH (Mμ) - 590Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S#23	23	16	67	239	213	196	65	44	1	0	0	859
S#20	7	0	9	52	101	62	97	23	11	3	0	365
S#26	0	0	0	1	43	130	73	105	6	1	0	359
S#33	0	0	7	44	149	137	65	94	54	34	0	582
S#30	0	0	0	55	22	28	19	19	3	6	0	153
S#52	0	2	19	35	30	29	26	16	3	2	0	162
Mean	5.0	3.0	17.0	71.0	93.0	97.0	57.5	50.2	13.0	7.7	0.0	413.3

WAVE LENGTH (Mμ) - 570Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S#34	1	1	8	29	48	45	46	26	33	9	4	251
S#31	6	12	29	83	77	29	46	9	0	1	6	298
S#40	6	16	50	51	65	55	65	36	19	1	0	364
S#43	0	4	75	119	92	43	15	5	0	0	0	353
S#37	12	1	13	143	160	104	61	15	15	4	3	573
S#62	1	7	13	63	66	57	80	53	21	1	0	362
Mean	4.3	6.8	31.3	81.3	84.7	55.5	52.2	24.0	14.7	2.7	2.2	366.8

WAVE LENGTH (Mμ) - 558Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590	Total
S#22	10	54	107	207	220	80	118	15	1	1	0	818
S#25	0	1	11	119	188	210	56	31	1	0	0	607
S#32	0	0	48	114	143	53	4	0	0	0	0	362
S#29	0	0	40	99	130	35	34	9	2	37	0	386
S#38	0	3	26	102	133	65	12	1	0	0	0	342
S#68	7	2	4	7	29	17	21	7	0	0	0	94
Mean	2.8	10.0	39.3	108.0	140.5	76.7	40.8	10.5	0.7	6.3	0.0	434.8

Table XXX

POST-DISCRIMINATION GENERALIZATION GRADIENTS
(PER CENT OF TOTAL RESPONSES)
60% GROUP

	510	520	530	540	545	550	555	560	570	580	590
					WAVE LENGTH (Mμ) - 590Mμ GROUP						
S# 1	2	0	1	5	14	20	9	21	9	7	12
S#55	0	0	0	5	12	19	21	21	19	4	0
S#49	1	0	5	19	29	25	12	5	3	0	0
S#58	0	1	7	19	18	19	16	14	5	0	0
S#69	0	0	6	19	20	15	14	11	11	3	1
S#74	2	1	2	12	12	14	21	19	13	5	1
Mean	0.8	0.2	3.5	13.2	17.5	18.7	15.5	15.2	10.0	3.2	2.3
					WAVE LENGTH (Mμ) - 570Mμ GROUP						
S# 2	0	1	16	13	19	35	1	12	4	0	0
S# 5	1	2	4	23	18	15	19	10	4	3	1
S#14	0	3	10	17	14	24	11	14	5	0	1
S#50	1	0	19	21	25	19	8	2	3	0	0
S#56	9	11	15	18	15	15	7	7	2	0	0
S#70	0	1	2	14	21	18	20	15	6	3	1
Mean	1.8	3.0	11.0	17.7	18.7	21.0	11.0	10.0	4.0	1.0	0.5
					WAVE LENGTH (Mμ) - 550Mμ GROUP						
S# 6	0	0	1	27	25	27	24	12	3	1	0
S#15	0	0	4	25	29	32	6	3	0	0	0
S#63	0	2	7	25	26	25	15	1	0	0	0
S#54	1	1	4	24	26	21	15	8	0	0	0
S#66	1	7	6	12	32	14	15	8	3	0	2
S#51	0	0	4	20	31	20	16	7	1	0	1
Mean	0.3	1.7	4.3	19.0	28.0	23.2	15.2	6.5	1.2	0.2	0.5

Table XXXI

POST-DISCRIMINATION GENERALIZATION GRADIENTS
(PER CENT OF TOTAL RESPONSES)
70% GROUP

	510	520	530	540	545	550	555	560	570	580	590
					WAVE LENGTH (Mμ) - 590Mμ GROUP						
S#13	0	0	0	12	14	25	16	20	7	5	0
S#16	0	0	0	4	11	31	29	18	5	1	0
S#45	0	0	0	2	21	25	34	16	2	0	0
S#42	1	2	3	17	18	25	16	15	4	11	0
S#36	0	1	10	16	13	20	20	15	5	0	0
S#39	2	1	3	12	16	31	18	11	5	1	1
Mean	0.5	0.7	2.7	10.5	15.5	26.2	22.2	15.8	4.7	3.0	0.2
					WAVE LENGTH (Mμ) - 570Mμ GROUP						
S#46	0	0	3	22	23	28	8	9	6	1	0
S#47	0	1	1	5	13	23	23	21	10	2	0
S#65	0	0	0	11	14	25	28	12	5	4	0
S#53	0	1	0	20	25	27	14	14	0	0	0
S#59	2	3	7	11	22	21	15	15	4	0	1
S#72	2	2	13	13	16	20	14	10	5	3	1
Mean	0.7	1.2	4.0	13.7	18.8	24.0	17.0	13.5	5.0	1.7	0.3
					WAVE LENGTH (Mμ) - 558Mμ GROUP						
S#12	0	1	5	16	30	22	18	7	1	0	0
S#18	0	0	7	32	49	12	1	0	0	0	0
S#60	0	0	5	12	20	29	22	8	3	0	0
S#67	1	2	12	26	25	19	11	5	1	0	0
S#44	0	0	4	40	37	13	5	0	1	0	0
S#48	1	1	4	18	20	22	1	16	5	3	0
Mean	0.3	0.7	6.2	24.0	29.8	19.5	11.3	6.0	1.8	0.5	0.0

Table XXXII

POST-DISCRIMINATION GENERALIZATION GRADIENTS
(PER CENT OF TOTAL RESPONSES)
80% GROUP

WAVE LENGTH (Mμ) - 590Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590
S#20	2	0	2	14	28	17	27	6	3	1	0
S#23	3	2	8	28	24	23	8	5	0	0	0
S#26	0	0	0	0	12	36	20	29	2	0	0
S#30	0	0	0	36	14	19	12	12	2	4	0
S#33	0	0	1	8	26	24	11	16	9	6	0
S#52	0	1	12	22	19	18	16	10	2	1	0
Mean	0.8	0.5	3.8	18.0	20.5	22.8	15.7	13.0	3.0	2.0	0.0

WAVE LENGTH (Mμ) - 570Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590
S#31	2	2	4	10	15	15	15	12	11	3	1
S#34	0	0	3	12	19	18	18	10	13	4	2
S#40	2	4	14	14	18	15	18	10	5	0	0
S#43	0	1	21	34	26	12	4	1	0	0	0
S#37	2	0	8	24	28	22	11	3	3	1	1
S#62	0	2	4	17	18	16	22	15	6	0	0
Mean	1.0	1.5	9.0	18.5	20.7	16.3	14.7	8.0	6.3	1.3	0.7

WAVE LENGTH (Mμ) - 550Mμ GROUP

	510	520	530	540	545	550	555	560	570	580	590
S#22	1	7	14	25	26	10	14	2	0	0	0
S#25	0	0	2	18	31	35	9	5	0	0	0
S#29	0	0	10	26	34	9	9	2	1	10	0
S#32	0	0	13	31	40	15	1	0	0	0	0
S#38	0	1	8	30	39	19	4	0	0	0	0
S#68	7	2	4	7	31	18	22	7	0	0	0
Mean	1.3	1.7	8.5	22.8	33.5	17.7	9.8	2.7	0.2	1.7	0.0

Table XXXIII

MEAN VALUES OF ALL GENERALIZATION GRADIENTS OF Ss
60% GROUP

	1	2	3	4
590 Mμ Group				
S# 1	550.06	558.91		
S#58	552.77	548.48		
S#49	559.16	547.11		
S#69	562.20	551.10		
S#55	556.48	557.00		
S#74	561.55	554.94		
570 Mμ Group				
S# 2	560.56	548.19	546.59	
S# 5	557.22	554.83	548.99	549.09
S#14	554.27	547.10	544.31	547.86
S#50	547.59	543.53		
S#56	551.70	536.98	539.34	
S#70	553.31	553.93	551.87	
558 Mμ Group				
S#15	552.47	544.56	542.24	546.18
S# 6	546.05	551.39		
S#63	554.11	544.96		
S#54	543.88	546.99	546.26	
S#66	559.42	554.87	554.04	546.20
S#51	563.38	555.48	547.65	

Table XXXIV

MEAN VALUES OF ALL GENERALIZATION GRADIENTS OF Ss
70% GROUP

	1	2	3	4	5
590 Mμ Group					
S#13	568.32	553.72			
S#16	553.36	553.43			
S#42	554.49	549.48			
S#36	554.57	549.25			
S#39	550.03	550.26			
S#45	555.49	552.40			
570 Mμ Group					
S#46	554.68	548.09	548.89		
S#47	556.62	549.58	549.81	554.38	
S#53	557.24	548.46			
S#59	562.38	557.61	549.82	548.45	
S#65	557.99	552.62			
S#72	556.67	557.64	555.30	547.53	
558 Mμ Group					
S#12	551.91	545.42	545.27	547.22	
S#18	552.62	544.20	547.29	546.34	542.97
S#44	557.32	547.80	545.86	543.94	
S#48	557.31	554.91	556.32	550.19	550.07
S#60	559.71	555.46	549.94	549.21	
S#67	557.37	549.46	540.03	544.13	

Table XXXV

MEAN VALUES OF ALL GENERALIZATION GRADIENTS OF Ss
80% [illegible]

590 Mμ Group

	1	2	3	4	5	6
S#20	559.25	556.58	548.74			
S#23	545.81	554.47	553.82	549.52	543.73	
S#26	553.25	553.73				
S#30	556.91	549.11				
S#33	553.99	553.49				
S#52	554.85	546.73				

570 Mμ Group

	1	2	3	4	5	6
S#43	547.[illegible]	545.46	541.55	541.09		
S#34	552.72	553.28				
S#40	548.39	545.18	543.40	545.99		
S#37	554.42	554.30	550.32	545.45		
S#31	557.65	549.83	544.92	544.06		
S#62	558.55	548.28	549.75			

558 Mμ Group

	1	2	3	4	5	6
S#32	548.60	550.85	542.28			
S#38	550.65	547.90	545.04	543.49		
S#25	558.26	548.62	546.57	545.87	547.25	
S#22	559.24	544.80	539.47	548.66	544.63	541.78
S#29	551.74	544.67	544.41	547.33		
S#68	545.97	542.60	545.11			

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